MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

EOS Ground System Architecture Description Document

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Preface

This document is final and complete. It has been reviewed by Goddard Space Flight Center and Computer Sciences Corporation personnel and conforms to all publication quality standards.

Questions concerning this document or proposed changes shall be addressed to

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Abstract

The Earth Observing System (EOS) Ground System (EGS) is a pivotal element of NASA's long-term effort in the study of the Earth's environment. It is an integrated system of unique, dedicated, and shared subsystems and services that provide test, launch, and on-orbit operations for numerous Earth Observing missions. The unique and dedicated portions of the EGS make up most of its size, scope, and capability, complemented by shared or institutional subsystems.

This EGS Architecture Description Document (ADD) describes the EGS architecture, including its hardware and software components, communications connections, and end-to-end mission data flow.

This document provides an overview of the EOS program, which places in context the EOS Space System (flight spacecraft and instruments), the Integrated Science Research Program (science objectives and the user community), and the EGS.

All the components that together comprise the EGS are addressed in some detail. Component descriptions are provided for the EGS that are unique and dedicated to EOS, for the NASA Institutional Support System, and for those systems that provide spacecraft ground support. The unique and dedicated subsystems are discussed first, reflecting their dominant role in the total system.

Appendix A describes the various missions related to the EOS program but not specifically dedicated to EOS. Appendix B provides further information on EOS spacecraft and instruments. Appendix C discusses three major development efforts for the EGS. A glossary of terms and an acronym listing are also included.

Keywords: *ADD, Architecture, EGS, EOS, EOSDIS, EOS Ground System, ESDIS, NESDIS, MTPE*

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Section 1. Introduction

The Earth Observing System (EOS) Ground System (EGS) is the pivotal element of NASA's 20-year effort to support international research into the Earth's environment. With the Space System and the Scientific Research Program, the EGS will fulfill NASA's Mission to Planet Earth, a crucial part of the U.S. Global Change Research Program. Figure 1-1 shows the context of the EGS within the Mission to Planet Earth and the U.S. Global Change Research Program. The reader is urged to explore the web sites listed in Section 1.4 to obtain a broad background and context for EOS in the national and international science initiatives.

The EGS is the integrated system of NASA institutional services, hybrid capabilities, and EOS unique subsystems that provides test, launch, and on-orbit operations services. The key element of the EGS is the EOS Data and Information System (EOSDIS). EOSDIS will include Earth science data not only from EOS spacecraft but also from several other sources. It will provide command and control of EOS spacecraft and instruments and will process, archive, manage, and distribute the Earth sensing data and information to the research community.

Figure 1-2 shows the EGS and the internal relationships of its elements, including EOSDIS. For perspective, most of the solid colors of both boxes and lines denote unique capabilities developed for EGS by the ESDIS Project. The complexity of this diagram gives "just a first" impression of the complexity of the EGS architecture.

1.1 Purpose/Scope

The purpose of this EGS Architecture Description Document (ADD) is to describe the EGS architecture, including the hardware/software components and the communications connections among those components. Emphasis is placed on the unique and dedicated components and subsystems that make up the majority of the ground system. This ADD identifies components and interfaces and provides an end-to-end view of mission data flow. This document also addresses how design drivers influence the architecture of each system, segment, and subsystem that make up the total EGS. It describes data paths from the EOS instruments through the EGS components in which the data are communicated, stored, processed, and made available to instrument builders, investigators, scientists, scholars, operators, and the public.

This ADD was created in April 1993, and has been revised and updated many times since. The contents of this ADD will be updated as the designs of the EGS components evolve, and at least once per year.

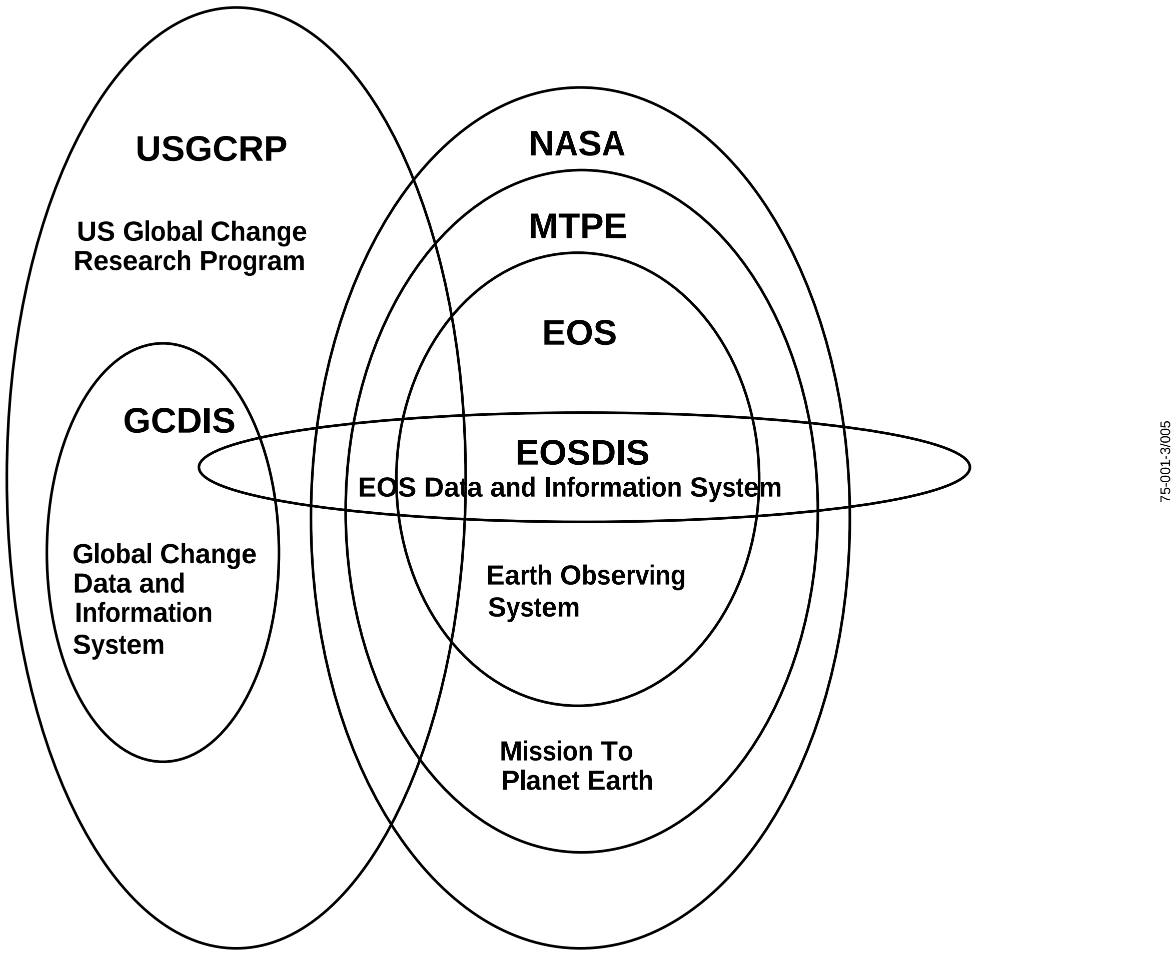

Figure 1-1. Venn Diagram of EOS Mission

Figure 1-2. EOS Ground System

1.2 Document Organization

The ADD is organized into three major sections: Introduction, EOS Program Overview, and EGS Component Descriptions. In addition, appendices describe EGS support of EOS related missions and include other information, such as how the EGS is being developed and the philosophy behind that development. The sections are designed to aid the reader in understanding the scope and architecture of the EGS and how it is meant to be used.

Section 2 begins with an overview of the EOS Program. This section describes the EOS space system; the scientific research program and the user community; and the ground system. Section 3 provides the detailed description of the major EGS components, starting with the unique ones. Descriptions and design drivers are presented for the Science Data Processing System (SDPS), the EOS Operations Center (EOC), the EOS Data and Operations System (EDOS), the EOSDIS Backbone Network (EBnet), and then the NASA Institutional Support Systems (NISS). Section 3 also includes the EGS role in spacecraft development, test, and launch.

EGS supports many important science missions but provides services that are general in nature. For this reason, an architecture description does not readily refer to the supported missions, even though they are the reason for its existence. For completeness, Appendix A describes the role of the EGS in support of the Tropical Rainfall Measuring Mission (TRMM), Landsat-7, and Advanced Earth Observing System (ADEOS) missions. Appendix B provides additional information on the EOS spacecraft and instruments and characterization of the AM-1 mission. Appendix C describes the three major EOSDIS development efforts. A list of abbreviations and acronyms and a glossary of terms are also included.

1.3 Applicable Documents

The following documents were used to obtain data, background information, and interface specifications used throughout this document. The numerous interface requirements documents and interface control documents identified in the System Interface Control Plan and available on many WWW sites were also used as source materials.

DOCUMENT NUMBER & DATE	DOCUMENT TITLE
NP-215, 8/95	1995 EOS Reference Handbook
GSFC 170-01-01, Rev. A, 5/95	Execution Phase Project Plan for EOS, Rev. A
SDP Ver. 4.0, 6/96	Science Data Plan for the EOSDIS
ECS 194-00131, 4/94	Defining the Architectural Development of EOSDIS to Facilitate Extension to a Wider Data Information System

____________________, 3/95	EOS Ground System Integration and Test Philosophy White Paper
Intermetrics 1109, 8/96	EOS Ground System (EGS) Integration and Test Program Plan
423-10-01-0, 2/93	Overall ESDIS Project Requirements, Volume 0
423-10-01-1, 5/93	EOSDIS Core System (ECS), Volume 1
423-10-01-2, 3/92	EOS Data and Operations System (EDOS), Volume 2
515-4FRD/0294, 12/94	ETS Functional and Performance Requirements
505-10-33, 11/96	EOS AM-1 Detailed Mission Requirements (DMR)
423-10-01-5, 9/93	EOSDIS Version Zero, Volume 5
423-10-01-6, 12/95	EOSDIS Backbone Network (EBnet), Volume 6
423-10-44-4, 4/97	EOS Polar Ground Stations Phase 2 Requirements, Volume 7, Draft
DN-SE&I-010, 6/93	Baseline Description Document for the EOS-AM Spacecraft
423-41-02 Ch. 12, 7/95	Functional and Performance Requirements Specification for the ECS
FB9401V2, 3/94	EOSDIS Core System Science Information Architecture
ECS 194-401-VE1-002, 6/94	Verification Plan for the ECS Project
319-CD-006-001/402-CD-003-001, 10/95	Release B System and Segment Integration and Test Plan for the ECS Project
604-CD-002-001/3, 10/95, 3/96	Operations Concept for ECS Project: ECS Release B
305-CD-040-001, 10/95	Flight Operations Segment Design Specification for the ECS Project
305-CD-020-002, 3/96	Release B SDPS/CSMS Design Specification Overview

560-EDOS 0202.0001, 12/92	Earth Observing System (EOS) Data and Operations System (EDOS) Functional and Performance Requirements
560-EDOS 0922.0001.R2, 3/94	Earth Observing System (EOS) Data and Operations System (EDOS) System Implementation Plan, Rev. 2
540-028, 5/96	EBnet Operations Concept Document
505-10-20, 12/96	System Interface Control Plan for the Earth Science Data and Information System (ESDIS) Project, Revision A
_________, 6/96	EOS Ground System (EGS) System and Operations Concept
_________, 6/96	EOS Mission Operations Concept
STX/EOSDIS 91-01, 12/91	EOS Science Operations Concept
333-CD-001-002	SDP Toolkit Users Guide for the ECS Project
193-801-SD4-001, 10/93	PGS Toolkit Requirements Specification for the ECS Project, Final [A.K.A GSFC 423-06-02]

1.4 EOSDIS-Related World Wide Web Sites

Table 1-1 lists EOSDIS-related World Wide Web sites. Readers are urged to explore these web sites for information and understanding of the context of EOS and the global science and investigator communities.

Table 1-1. ESDIS-Related WWW Sites

EOSDIS-Related Homepage	URL	Contents
Mission to Planet Earth	http://www.hq.NASA.gov/office/mtpe	Information on missions, science, data access, news, publications, education
Earth Observing System Homepage	http://eos.nasa.gov/	Access to program information; NASA, DAACs, ECS servers information
Welcome to the Global Change Master Directory	http://gcmd.gsfc.nasa.gov/	Global change master directory, directory news, documentation; pointers to other servers
EOSDIS Information Management System (IMS) Homepage	http://harp.gsfc.nasa.gov/vOims/	Information about EOSDIS IMS, EOSDIS data search and order tools, IMS documents, EOSDIS on display, and data product types and services
ESDIS System Management Office (SMO) Homepage	http://esdis.gsfc.nasa.gov/smo/ smo.html	SMO schedules, documentation, briefings, presentations, activities, events, metrics, and information desk
EOSDIS Core System (ECS) ECS Information	http://ecsinfo.hitc.com/	ECS definition, newsletter, ECS at DAACs, prototypes, science data production, user feedback; link to ECS Data Handling System (EDHS) and Earth pages
EOSDIS Test System Homepage	http://esdis.gsfc.nasa.gov/ETS/ets.html	Information and status of the EOS Test System
EBnet Homepage	http://bernoulli.gsfc.nasa.gov/EBnet	Documentation, EBnet traffic database, presentation material
EOSDIS	http://spsosun.gsfc.nasa.gov/EOSDIS_ main.html	Informattion on EOSDIS, access to data and services, system architecture and technology, organizations, publications, activities, and schedules
EOS Project Science Office	http://eospso.gsfc.nasa.gov	EOS investigations, mission profiles, publications, education, directory, EOS-related servers
Science Data Plan	http://spsosun.gsfc.nasa.gov/spso/sdp/ sdphomepage.html	Science data plan for EOSDIS Homepage
Earth Pages	http://starsky.hitc.com/earth/earth.html	a search and index tool to help navigate the internet for earth science
EOS AM Project	http://fpd-b8-0001.gsfc.nasa.gov/421/ 421home.htm	Missions, management, flight projects
Landsat Program	http://fpd-b8-0001.gsfc.nasa.gov/430/ 430home.htm	Program news, summary, chronology, Landsat 7 Summary
SAGE III Homepage	http://arbs8.larc.nasa.gov/sage3/	SAGE Introduction, science team, organization, missions, metrics, events, documentation, objectives description, etc.

Section 2. EOS Program Overview

The overall goal of the EOS mission is to advance the scientific understanding of the entire Earth system on a global scale by developing a greater understanding of the geophysical parameters of the Earth system, the interactions among them, and the way the Earth is changing.

The EOS program mission objectives are as follows:

- To create an integrated scientific observing system emphasizing climate change, causes, processes, and effects that will enable multidisciplinary study of the Earth's critical, life-enabling, interrelated processes involving the atmosphere, oceans, land surface, polar regions, and solid Earth, and the dynamic and energetic interactions among them.
- To develop a comprehensive data and information system, including a data retrieval and processing system, to serve the needs of scientists performing an integrated multidisciplinary study of planet Earth.
- To acquire and assemble a global database of remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of Earth system attributes. The EOS program provides the science user community with data and the supporting information system necessary to develop a comprehensive understanding of the way the Earth functions as a global system.

The three primary components of the EOS program and their purposes are as follows:

1) **The EOS Space System**—to acquire essential global Earth science data on a long-term sustained basis and in a manner that maximizes the scientific utility of the data and simplifies data analysis.
2) **The Integrated Scientific Research Program**—to investigate processes in the Earth System and improve predictive models.
3) **The EOS Ground System**—to provide the Earth science research community with easy, affordable, and reliable access to the full suite of Earth science data from U.S. and IP platforms.

Figure 2-1 shows the relationship of these EOS components.

2.1 EOS Space System

The EOS Flight and Observing System consists of a series of predominantly polar-orbiting spacecraft. The United States, the European Space Agency (ESA) and Japan’s National Space Development Agency (NASDA) are scheduled to fly EOS missions. Table 2-1 summarizes the EOS-era missions currently planned.

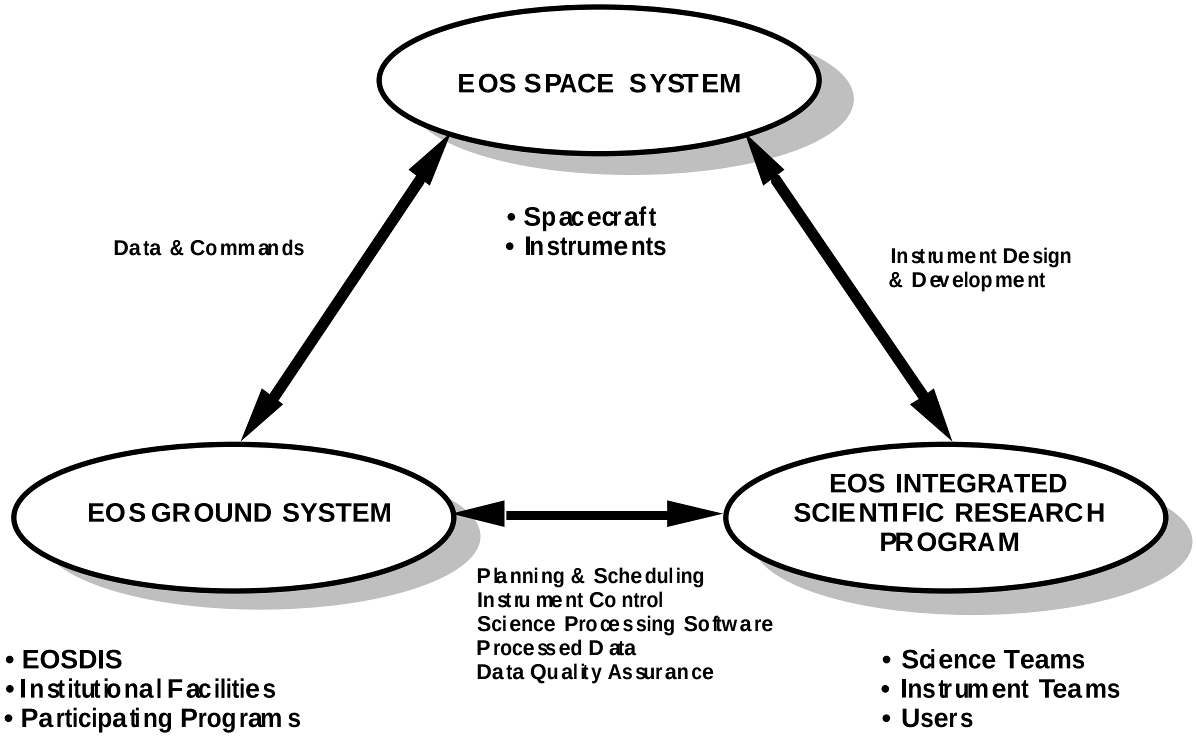

Figure 2-1. Major EOS Segments

Table 2.-1. Planned EOS-Era Missions

Country	Program	Spacecraft	Launches (Tentative)
United States	Earth Observing System (EOS)	AM series	1998, 2004
		PM series	2000, 2006
		LALT series	2002, 2007
		CHEM series	2002, 2008, 2008
ESA	Polar-Orbit Earth Observation Mission (POEM)	ENVISAT series	1998
		METOP series	2000
Japan	Japanese Earth Observing System (JEOS)	ADEOS II	1999

Four series of U.S. EOS spacecraft are planned, each with a different flight configuration based on scientific measurement objectives. During EOS’s projected 20-year operational lifetime, as many as four spacecraft (one from each series) may be operating simultaneously. In addition, two spacecraft from the same series may be in orbit during a spacecraft crossover replacement period of up to 6 months. The *Execution Phase Project Plan for Earth Observing System (EOS)* and the documentation associated with each mission provide more detailed information about each series. Figure B-1 in Appendix B of this document provides additional EOS mission profile information.

The scientific instruments for the NASA EOS spacecraft are divided into two classes, facility instrument and principal investigator (PI) instrument. Facility instruments measure variables useful to a wide range of science disciplines; PI instruments observe more specific phenomena. Many instruments have been selected or are in the process of being selected to be flown on the U.S. EOS series of spacecraft. In addition to these EOS spacecraft, EOS-funded Flight of Opportunity (FOO) instruments will be flown on other U.S. and international spacecraft. For details about the EOS instruments, see the *EOS Reference Handbook.*

The AM-1 spacecraft will use the Space Network (SN) Tracking and Data Relay Satellite System (TDRSS) as its initial space-to-ground communications link. It will also have an X-band capability that will be used in the event of a failure in the primary downlink communications path. For all subsequent NASA EOS spacecraft, the primary communications link will be an X-band downlink to dedicated EOSDIS ground stations. The X-band sites will also provide S-band command and control links, although all EOS spacecraft will retain capabilities for using the SN for command and control. The AM-1 spacecraft may change to X-band site support also.

2.2 Integrated Scientific Research Program

The Integrated Scientific Research Program focuses on the utilization of EOS data. It includes funding for postgraduate fellowships in the area of global change, for interdisciplinary investigators (IIs) performing integrated studies of the Earth to enhance the capability to predict global change, and instrument investigations to focus on the development of and utilization of data from particular instruments.

The Integrated Scientific Research Program is led by the science/user community. The scientists determine the observations to be made. The PIs and Co-Investigators (Co-Is) help the instrument engineering teams build the instruments required to collect the data. The science teams plan and schedule the use of the instruments. The scientists provide science algorithms for generating data products and performing quality assurance on the generated products. They also analyze the data from the EOS instruments, publish the results, and make recommendations for the global change research community.

The other EOS investigators supported by the research program include research facility instrument Team Members (TMs), led by their Team Leaders (TLs), who make use of the facility instruments being developed by the EOS project; and the IIs, who are interested in the analysis and interpretations of data from EOS instruments and related data from other sources.

2.2.1 Science Objectives

The science objectives determine the EOS missions and science instruments to be flown on these missions. Most of the science instruments are developed by and are the responsibility of NASA centers, such as Jet Propulsion Laboratory (JPL), Langley Research Center (LaRC), and Goddard Space Flight Center (GSFC). These centers, in many cases, also house the PI and the Distributed

Active Archive Centers (DAACs) responsible for these instruments. DAACs will process, archive, and distribute science data to the user community. EOSDIS builds on existing discipline-specific Earth science data centers and data systems. NASA initially selected eight DAACs to carry out the responsibilities for EOSDIS data management. These assignments were based primarily on the current distribution of expertise and activities.

Table 2-2 shows the major science objectives for each series. More information on science objectives is available in the EOS Reference Handbook and on the World Wide Web.

Table 2-2. Summary of EOS Science Objectives

Series	Major Science Objectives
AM	Characterization of the terrestrial and oceanic surfaces
	Clouds, aerosols, and radiation
	Radiative balance
	Sources and sinks of greenhouse gases
PM	Cloud formation, precipitation, and radiative balance
	Terrestrial snow and sea ice
	Sea-surface temperature and ocean productivity
LALT	Ice sheet mass balance
CHEM	Atmospheric chemical species and their transformations

2.2.2 User Community

The EOS user community includes PI/TLs/TMs, the IIs, the international science users, and the general science users. Social scientists have collaborative access through the Socio-Economic Data Applications Center (SEDAC) DAAC, and educational organizations represent a large segment of the intended user population. The reader is referred to the web sites listed in Section 1.4 for further explicit information on these topics.

2.2.2.1 Principal Investigators, Team Leaders, and Team Members

There are major perspectives within the user community, such as instrument-oriented users and discipline-oriented users. An instrument-oriented user is concerned with how to best use the data from a given instrument to learn more about the environment. This user is particularly interested in how to best calibrate the instrument and validate its data products; this user is also interested in developing new sensing techniques. The discipline-oriented user is usually a PI or Co-I associated with an interdisciplinary science team. Their interest is likely to involve use of data from multiple instruments to tackle a science problem.

Within the user community, there is a further distinction between investigators interested in global data sets and investigators oriented towards regional data. The two geographic interests are important for such data operations as subsetting and data examination. A global investigator is likely to want overviews and latitudinal averages as part of his searches for meaningful data. A regional investigator is likely to want to look at small portions of the Earth with many different kinds of data. The investigator needs subsets of many of the standard data products. Design of EOSDIS accommodates the discipline-oriented investigators' requirement for global modeling. This activity requires a large number of diverse inputs, and large volumes of data are generated by running the model.

Instrument investigations are performed by a group of scientists responsible for the design, development, test, calibration, operation, algorithm development, and data analysis for Earth observing instruments. These scientists, under the leadership of the PI, plan and conduct research; reduce, analyze, and interpret data; and publish their results. The PI ensures that the experiment definition; instrument design and development; planning and support of mission operations; and data validation, quality control, analysis, and publication are successfully carried out. The Co-Is assist the PI in meeting his/her responsibilities and participate in the group's operation as defined in a Science Management Plan.

A Facility Instrument Team consists of selected scientists who can contribute substantially to guiding the design, development, test, calibration, operation, data reduction, or algorithm development of a facility instrument. The Facility Instrument TMs function in a manner similar to the Co-Is on an instrument investigation. Each team is organized under the direction of a TL. The TL has primary responsibility for conducting the team's investigation as well as directing team activities.

The PIs and/or the Instrument Team Leaders perform a special role within the user community. They utilize the SCFs, where new algorithms are developed and updated, special data sets are produced, and data quality checking is performed. The Instrument Working Group and the Project Scientist provide long-term science plans; PIs and TLs contribute to this effort.

2.2.2.2 Interdisciplinary Investigators

IIs are a group of scientists interested in the analysis and interpretation of data from EOS instruments as well as data from other sources. This participation is intended to exploit the synergistic nature of the EOS experiments so that the multidisciplinary scientific tasks of EOS are adequately addressed, to help guide the development of EOSDIS, and to provide a strong theory and data analysis perspective to mission planning. In addition to analyzing data, these investigations may include the development of theoretical models whose capabilities and results will be made available to the EOS investigator community. The IIs, under the leadership of the PI, plan and conduct the research, analyze and interpret EOS and non-EOS data, and publish their results.

The EOS IIs are supportive of two main themes:

1. The Earth System can be subdivided into several components: atmosphere, ocean, land biosphere, fresh water, snow, and ice. State variables associated with these various components can be estimated from measurements with the EOS instruments.

2. The cycles that link various parts of the Earth System can be identified: energy and momentum balance, the hydrologic cycle, the biogeochemical cycle, and ecosystem dynamics. Most of the interdisciplinary investigations address these links between components.

2.2.2.3 International Science Users

The International participants, ESA and Japan, provide data acquisition, processing, archiving, and distribution capabilities in support of their spacecraft, instrument payloads, and satellite communications relay. Each participant has a ground system for data processing and distribution.

These ground systems provide for the exchange of spacecraft and payload data. All agencies exchange data and support planning and scheduling, commanding, and operations of instruments on their respective spacecraft. U.S. spacecraft carry instruments from several countries, requiring commanding support as well as data processing and exchange services. U.S. participants require data from international payloads on any of the spacecraft, and the international participants require access to U.S. payload data for their processing and/or investigations. EOSDIS provides for the exchange of data between the United States and the international databases. A NASA Headquarters Memorandum of Understanding (MOU) defines the interface between the IPs and the EOS program.

ASTER is a facility instrument provided by Japan's MITI under an agreement with NASA. Architecturally similar to ECS in functionality and operational concept, the ASTER Ground Data System (GDS) is composed of three segments : the ASTER Operations Segment (consisting of the ASTER IST and ICC), the Communications and Systems Management Segment (CSMS), and the SDPS.

2.2.2.4 General Users

The user community extends past the boundary of mission-selected research scientists (the PI, Co-I, and TL/TM) associated with a particular instrument or research investigation. EOS data and information is used by the broader operational and research communities, including such groups as U.S. and international operational agencies and the international Earth science research community at academic and government institutions. Researchers at academic and governmental institutions who are not affiliated with the EOS program can access the EOSDIS catalogs and order EOS products. In particular, the EOS data system provides access to data for research programs of other U.S. Government agencies (e.g., the U.S. Geological Survey and the National Forest Service).

2.3 EOS Ground System

2.3.1 EGS Overview

The EGS is an integration of EOS spacecraft ground support, science investigator support, data centers, IP ground stations, user networks, non-EOS ground systems, contractor facilities, NASA institutional support, and EOSDIS. EOSDIS is the dedicated and unique portion of the EGS developed by the ESDIS Project.

EOSDIS, as the NASA overall Earth science discipline data system, provides the ground system for the collection and analysis of science data to support scientists in resolving the dynamics of the Earth’s components and the processes by which they interact. As a part of the EOS program, EOSDIS supports the planning, scheduling, and control of the EOS series of spacecraft, exchanging commands, data, and algorithms with ESA, Japan, Canada, the National Oceanic and Atmospheric Administration (NOAA), and any other non-NASA entities involved in the overall EOS mission. EOSDIS is also responsible for coordinating these activities with other data-gathering systems and transforming the observations into physical variables, providing for higher levels of processing, and presenting the data to users in forms that facilitate and stimulate interactive scientific research. EOSDIS supports NASA Earth Probe missions (non-EOS NASA Earth science flight projects) and adds to its database other selected non-EOS data that are required for use in conjunction with EOS data. EOS, Earth Probe, and other selected non-EOS data and products are cataloged, archived, and retrieved in a manner that supports the scientist in developing a better understanding of the way the Earth functions.

Table 2-3 summarizes the major elements of EGS.

Section 3 of this document provides more details on the components that make up the EGS, including design drivers for each component. Figure 2-2 is a Venn diagram of EGS. Included in this diagram are the section numbers in this document where more information can be found on individual systems. Figure 2-3 summarizes the EGS components and interfaces. (See Figure 1-2 for a detailed interface diagram depicting the overall EGS architecture.)

2.3.2 EGS Environment

In general, the EOS AM-1 spacecraft transmits data through the Tracking and Data Relay Satellites (TDRSs), which forward the data to the receiving station at White Sands, New Mexico. From White Sands, the data are transmitted via circuits to GSFC, where these data are processed to recover the raw instrument data. IP satellites downlink directly to the IP Ground Systems via their ground receiving stations. Data from NASA instruments on the IP platforms are transmitted to GSFC via commercial networks. Landsat-7 downlinks data directly to the Landsat-7 Ground Station (LGS) at the EROS Data Center (EDC) and to International Ground Stations (IGSs).

For EOS missions subsequent to AM-1, the science data will be transmitted via high-latitude X-band EOSDIS ground stations in Alaska and Norway. These high-latitude ground stations will then forward the science data to GSFC.

Flight operations (including spacecraft and instruments) are conducted from the EOC. Non-U.S. instruments on U.S. platforms are operated and monitored through IP ICCs.

2.3.2.1 Distributed Active Archive Centers

DAACs were selected on the basis of scientific expertise, experience with data and information systems, and long-term institutional commitment to support the DAAC function for the EOS program.

Table 2-3. Summary of EGS Elements and Their Roles

EGS Element	Role
EOSDIS	
• EOSDIS Core System (ECS)	Provides EOS flight operations; science data processing; and EOSDIS communications and system management
• Distributed Active Archive Centers (DAACs)	Provides production, archive, and distribution of EOS and non-EOS science data products, and user support
• Version 0	Provides a working prototype of selected key EOSDIS services with some operational elements
• Science Computing Facilities (SCFs)	Provides science data processing software/algorithms, data product quality assessment, and user support
• EOS Data and Operations System (EDOS)	Provides EOS data capture, level 0 processing, and backup archive
• EOSDIS Backbone Network (EBnet) and External Network	Provides EGS mission operations communication services and science operations communication services
• EOSDIS Test System (ETS)	Provides test data generation and EGS element simulation capabilities
• EOSDIS Ground Stations	Provide space to ground communications services for post-AM-1 missions
Institutional facilities	
• Flight Dynamics	Provides orbit and attitude data, and orbit adjust and maneuver computations for EOS spacecraft
• Nascom	Provides communications services between the White Sands Complex (WSC) and EGS elements
• Space Network	Provides TDRSS services for AM-1 spacecraft and backup for post-AM-1 missions
Wallops Ground System (WGS)	Provide backup for low-rate communications services and scheduled telemetry and command services for selected missions
• X-Band Backup Ground Stations	Provide backup science data communications services for AM-1
Participating Programs	
• EOS Spacecraft Ground Support	Provides real-time spacecraft simulations, generation and test of flight software updates, integration and test facilities, operational launch support services, and spacecraft sustaining engineering facilities and services
• International Partner Facilities	Includes interfaces with international partner facilities such as the ASTER Ground Data System (GDS), and the NASDA Earth Observation Information System (EOIS)
• Affiliated Data Centers (ADCs) & Other Data Centers (ODCs)	Provides selected Earth science data and metadata to DAACs for archive and user access; examples include the Landsat Processing System (LPS), and the TRMM Science Data and Information System (TSDIS), and the NOAA Satellite Active Archive
• User Facilities	Provides user access to EOSDIS science data
• NASA Internet (NI)	Provides external communications services between EOSDIS and EOSDIS users

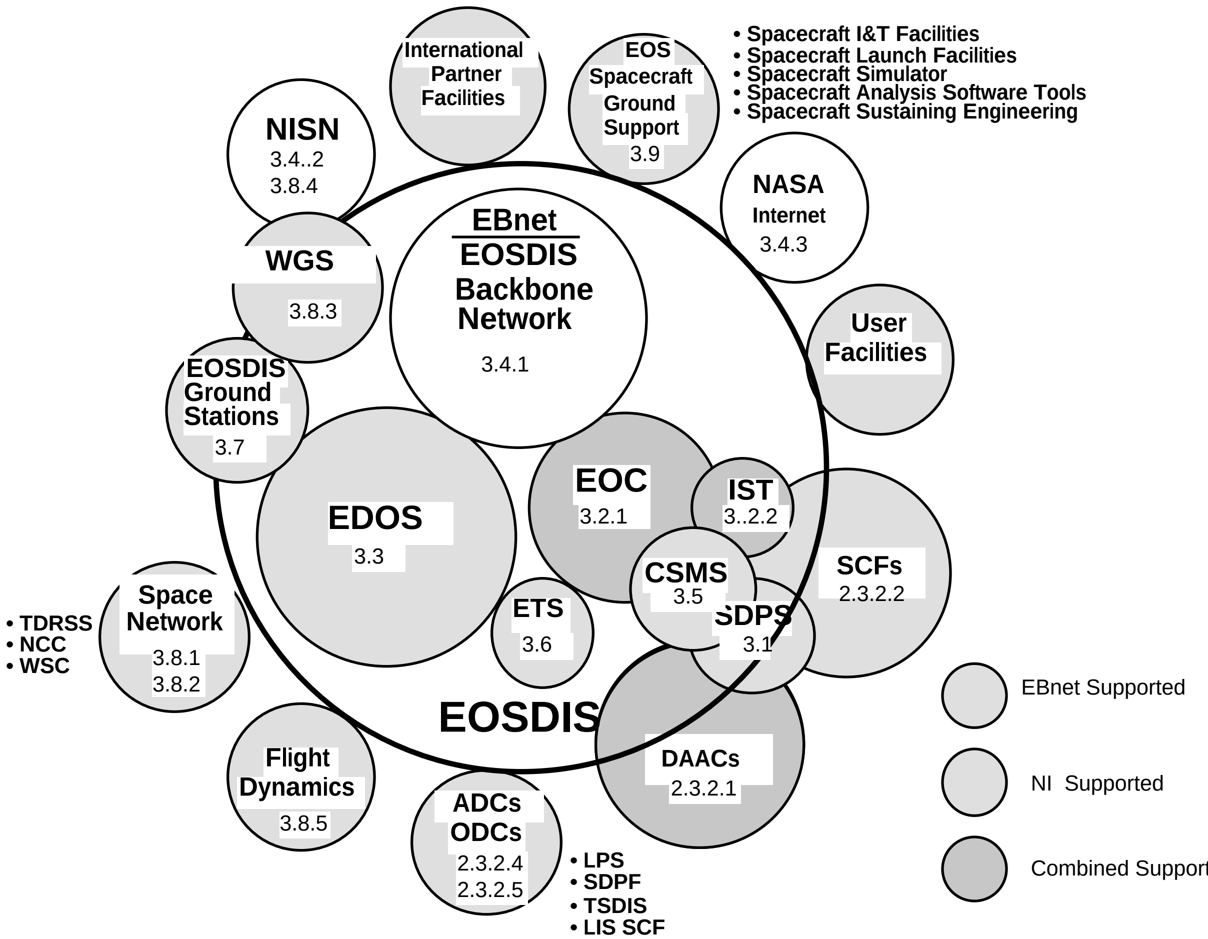

Figure 2-2. Venn Diagram of EOS Ground System

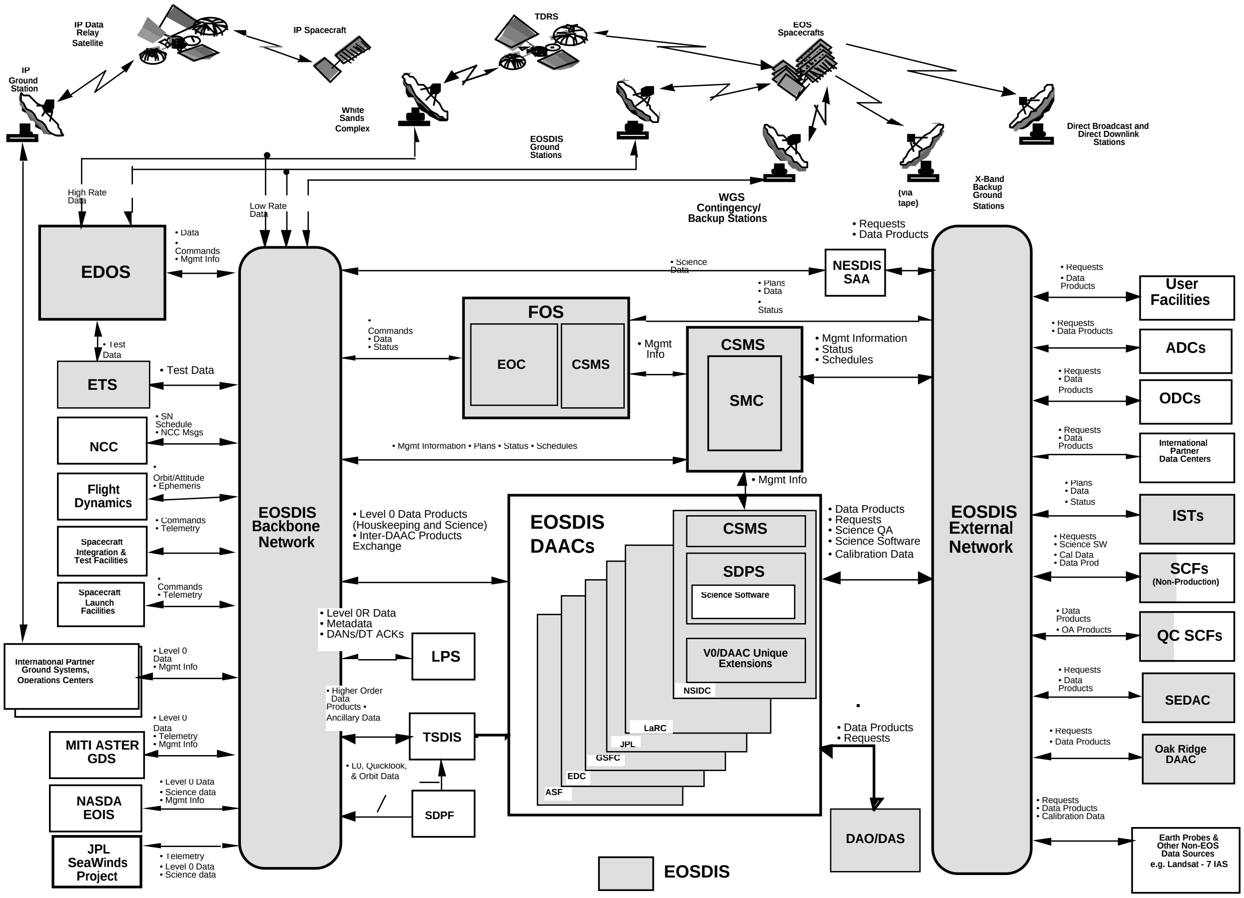

Figure 2-3. EGS Components and Interfaces

Under the general purpose of providing data and information services to users, DAACs have many responsibilities, including the following:

a) Preserve data for users by providing a secure data archive, all needed supporting information, and long-term maintenance. This includes existing NASA data, near-term flight projects, and the EOS mission (all Mission to Planet Earth [MTPE] data). DAAC archive is maintained until data are transferred to long-term archive.

b) Generate products to meet user requirements, using investigators' science software where appropriate.

c) Help users to quickly and easily locate and order data. This includes access to the Global Change Master Directory, tailored services for DAAC-specific discipline users, "one-stop shopping" for all NASA MTPE data for all users, and referrals to other DAACs and other agency data centers.

d) Distribute data to investigators using a common format to facilitate interuse of data sets. Data will be distributed using electronic distribution for rapid response and hard media for bulk requests. Each DAAC will interface with other DAACs for the purpose of routing EOS data products, browse and metadata information, and documentation required for interpretation; and distributing desired information and data products to the requested users.

e) Maintain operational user support offices and documentation of all data sets, including an online guide.

f) Pursue an active, responsive relationship with the User Working Group. (Each DAAC has a working group of users to provide advice on priorities for scientific data, levels of service, and the capabilities needed.)

g) Provide long-term user support for EOS products, even after instrument teams have gone on to other work. The DAAC staff will stay knowledgeable on EOS products to provide effective user support.

Most science users access EOS data products via the shared NSI. Open access to the data by all members of the science community distinguishes the EOS from previous research satellite projects, where selected investigators have had proprietary data rights for a number of years after data acquisition.

Each DAAC has an ongoing Earth science function that is augmented by the added EOSDIS capabilities. Table 2-4 summarizes the EOSDIS DAACs, their respective science disciplines, and the missions and instruments supported.

2.3.2.2 Science Computing Facilities

The SCFs are part of the computer facilities at investigators' institutions that are used for scientific research. The SCFs may range from single workstations to large supercomputer data centers.

The ESDIS Project provides each SCF with a science toolkit to allow communication with the DAACs for data product development and an instrument toolkit for instrument monitoring/control with the EOC. Using these toolkits, the scientists develop and validate their algorithms at the SCF and migrate the algorithms to the DAACs. Instrumenters can also monitor the status of their instruments and conduct performance analysis from the SCF, using the EOC. They may also schedule instrument activities with the EOC.

The primary functions of an SCF include the following:

- Support data production and science software development, including the development and maintenance of algorithms/software for producing data products.
- Support data analysis, visualization, and manipulation required for the scientist’s research
- Perform QC of standard products. (QC SCFs typically have subsets of the capabilities of the other SCFs.)

- Support instrument operations planning and scheduling and instrument performance monitoring and trending.
- Provide interfaces to the scientists' institutional computer facilities.
- Support data set validation, instrument calibration, and behavior analysis.
- Support generation of specialized products and computations required for the scientists' research.

Figure 2-4 provides an overview of the SCF interfaces with the EGS. This figure, and many others throughout this document, is a subset of Figure 1-2; reference to that figure will therefore provide additional context.

Table 2-4. DAAC Summary

DAAC	**Science Discipline Assignments Made**	**Mission/Platform**	**Instrument/Experiment**
Alaska SAR Facility (University of Alaska - Fairbanks)	Synthetic Aperture Radar Study, Polar Processes	ERS and JERS series RADARSAT	SAR SAR
EROS Data Center (USGS)	Land Processes Imagery	AM-1 Landsat-7	ASTER and MODIS (L2+/land) ETM
Goddard Space Flight Center (NASA)	Upper Atmosphere, Atmospheric Dynamics, Global Biosphere, Geophysics	TRMM SEASTAR ADEOS-I AM and PM series PM series Laser Altimeter CHEM-1 Flight of Opportunity (FOO)	VIRS (a/d) PR (a/d), TMI (a/d), GV (a/d) SeaWiFS TOMS (a/d) MODIS AIRS, AMSU, MHS, AMSR GLAS (LO/1) HIRDLS, MLS SOLSTICE III
Jet Propulsion Laboratory Interaction (Cal Tech)	Ocean Circulation and Air-Sea Interaction	ADEOS-I ADEOS-II Jason-1, Radar-Altimeter-2	NSCAT (a/d) Seawinds JMR, DFA, MR
Langley Research Center Tropospheric (NASA)	Radiation Budget, Aerosols, Chemistry	TRMM AM-1 AM-2 PM series, FOO FOO FOO, Meteor, and Space Station CHEM-1	CERES CERES, MISR, and MOPITT CERES, MISR, EOSP CERES ACRIM SAGE III TES
National Snow and Ice Data Center (U. of Colorado)	Cryosphere (non-SAR)	AM-1 and PM-1 PM-1 Laser Altimeter	MODIS AMSR GLAS (L2+)
Oak Ridge National Laboratory (DOE)	Biogeochemical Dynamics	None	None
Socio-Economic Data Applications Center (CIESIN)	Policy/Decision Making Applications of Combined MTPE and Socio-Economic Data	None	None

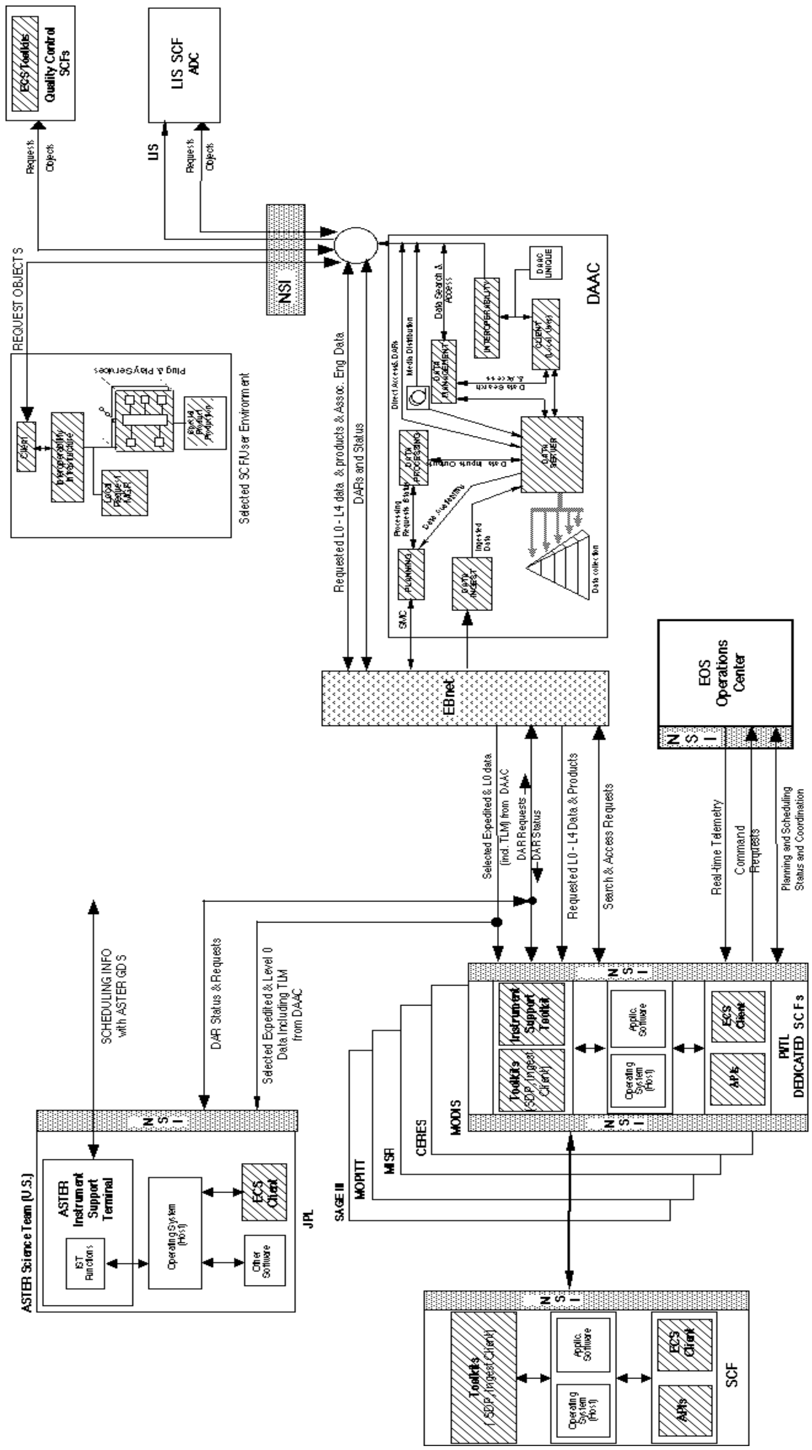

Figure 2-4. SCF Components and Interfaces

2.3.2.3 Data Assimilation Office/Data Assimilation System

The mission of the Data Assimilation Office (DAO) is to advance the state of the art of data assimilation and to use the assimilated data in a wide variety of Earth system problems. Data assimilation is the construction of global data sets that are physically and chemically consistent, from the many data sources in routine operations or from special research projects in a number of disciplines, including weather prediction, oceanography, and atmospheric chemistry. Much of these data come from satellite operations, using accurate calibrated instruments over long periods of time, albeit scattered in space and time. Data assimilation allows the formation of a time sequence of three-dimensional pictures of the Earth system. This work has been recognized as a national priority to assure that maximum information is obtained from the observational systems.

The Data Assimilation System (DAS) is the collection of software, hardware, and operations personnel employed and managed by the DAO to carry out its mission. Important parts of the DAS include the set of assimilation algorithms developed by the DAO, a large collection of dedicated processors and storage equipment to accommodate its workload, and a DAS scheduling facility. DAS is also a substantial user of EOSDIS planning and science processing resources. Figure 2-5 gives an overview of the DAS capabilities.

The DAO is responsible for developing assimilation algorithms used to produce research quality assimilated data products like the multiyear global atmospheric data sets. The input source data for all DAS modes are (1) First Look Input Data (FLID) and (2) measurements from different aircraft and satellite winds, along with National Environmental Satellite, Data, and Information Service (NESDIS) Operational Vertical Sounder (TOVS) retrievals and retrieval spot radiances. The output consists of large sets of gridded data in the global scope at fixed (usually 3 or 6 hour) time intervals. ECS, located at the GSFC DAAC, archives the DAS generated products and makes them available to the end users and instrument teams.

DAS performs preprocessing and postprocessing using DAO provided software. DAS submits subscriptions to ECS for any new data. DAS data requests are automated. DAO provided software running in the Data Reduction Platform (DRP) performs a statistical process that reduces the volume of data without sacrificing information content.

DAS supports different processing modes. Potentially, the first step in each mode is to spatially reduce the Instrument Team data. In some cases, the reduction factor is in the thousands. To minimize network traffic across a WAN, it is efficient to have the DRP located at the DAAC facility hosting the data perform this data reduction. In addition to the hardware platform, the DRP has attached disks to stage the data retrieved from the ECS. The following paragraphs provide a high-level description of the DAS processing modes.

2.3.2.3.1 Operations Mode

The Operations mode of DAS consists of both real-time and delayed processing. DAS, in its real-time operations mode, uses the FLID and generates the First Look Analysis and 10-Day Forecast products. These products are generated in real time, meaning that they are generated within a specific time window each day. DAS does not pull any data out of the ECS archives for these two product generation runs but provides the products for ECS at the GSFC DAAC to archive and distribute. The FLID is obtained from the GSFC DAAC.

In the Delayed Operations mode, DAS runs the Final Platform analysis to generate the Final Platform products. In addition to FLID, DAS uses EOS data for this run. Final Platform Analysis is referred to as Delayed Operations mode, because two asynchronous activities have to be completed before it can run. First, the First Look Analysis and 10-Day Forecast by DAS have to be completed, and the resultant products have to be made available to other Instrument Teams. Second, the Instrument Teams have to complete their processing, and the DAS obtains any resultant products to create the Final Platform.

2.3.2.3.2 Reanalysis Mode

In Reanalysis mode, the DAS sweeps through massive amounts of input data, a large amount of which the ECS archives at the GSFC DAAC. During a given 24-hour period, up to 30 days worth of data may be reprocessed. The throughput rates are, therefore, much higher than the Operations mode. In Reanalysis mode, as in Operations, DAS accepts FLID and EOS data as input and generates Offline Analysis, Pocket Analysis, and 20-Year Analysis products. ECS archives products from Reanalysis at the GSFC DAAC.

2.3.2.4 Affiliated Data Centers

Affiliated Data Centers (ADCs) allow access to non-EOS data sets to satisfy user queries and for use as ancillary data for standard product generation. ADCs share data and results with DAACs, supporting the science objectives of the EOS program. The ADCs include NESDIS, the National Center for Environmental Prediction (NCEP), the University of Wisconsin, the Incorporated Research Institutions for Seismology (IRIS) Data Center, and the Global Hydrology Research Center.

NOAA produces many atmospheric and oceanographic data sets and maintains several databases of key importance to the EOS research program. These include both Level 1 and derived geophysical products, some of which are routinely required to support the production or validation of EOS standard products.

Under a NOAA contract, the Space Science and Engineering Center of the University of Wisconsin maintains a long-term archive and distribution function for Level 1 data from NOAA GOES environmental satellites.

NESDIS is responsible for the operation of geostationary and polar orbiting meteorological satellites. NESDIS centers can access EOS data and provide data analyses reports back to the DAACs.

The NCEP and its Climate Analysis Center provide routine weather and climate forecasts for the United States. These are produced by operation of large-scale models that ingest data from a vast array of sources, ranging from ground observations to satellites. The products are of critical importance to the U.S. Global Change Research Program (USGCRP).

The IRIS data center located in Seattle, Washington, receives the Wide Band Data Collection System data from EGS. The National Science Foundation uses these data for analysis and collection of seismic and other scientific data.

The Global Hydrology Research Center (GHRC) is a data and information system that supports product generation, archival, and distribution of research quality and operational data sets. It provides access to the Lightning Imaging Sensor (LIS) data sets. The LIS SCF serves as the data production, archive, and distribution system for lightning data collected by the EOS lightning sensors.

The GHRC processes a variety of passive microwave data sets producing global tropospheric and stratospheric temperatures derived from the Microwave Sounding Unit and global tropospheric water vapor derived from the Special Sensor Microwave Temperature Sounder (SSM/T2). In addition, aircraft passive microwave data collected during field experiments using the Advanced microwave Precipitation Radiometer (AMPR) are available.

2.3.2.5 Other Data Centers

Other Data Centers (ODCs) provide access to data identified by EOSDIS users as required for their research but not available directly within EOSDIS or through ADCs. All ODCs are accessed by EOSDIS through GCDIS. Detailed EOSDIS requirements for ODCs are established as part of the negotiations with the data center. At minimum, each ODC shall be capable of fulfilling the following requirements:

- Provide a single point of access to EOSDIS
- Make its data system available to EOSDIS users
- Provide access to user services

Section 3. EOS Ground System Component Descriptions

The EGS and EOSDIS architecture and physical configurations have been designed on the basis of several key drivers so that EOSDIS will perform the following functions or have the following attributes:

- Support new modes of research and facilitate synergistic interactions between data from the EOS instruments and simulations with models developed by EOS researchers.
- Archive and provide access (interoperability) to usable scientific information to the geophysical, biogeochemical, ecological, and interdisciplinary communities, to be used by a wide spectrum of scientists and the public during the life of the EOS mission.
- Archive and provide access to standard, reliable data products that are essential to distinguish natural and anthropogenic variations so that the scientific community has access to independent measurements to validate and drive models of processes on local, regional, and global scales.
- Perform the command and control of the EOS instruments and the spacecraft to control the recoveries of data and provide the capability to monitor and react to the health and safety of the spacecraft systems and instruments.
- Be a user-driven (friendly) system that assures low-level system operations and configurations that are transparent to the user.
- Be a distributed system that incorporates display-oriented archives.
- Incorporate evolutionary methods for providing long-term archives and access to these archives.
- Optimize the use of commercial-off-the-shelf (COTS) components to provide use-tested, easily interchangeable, upgradable components and to reduce development costs.
- Provide interoperability among individual EOS systems, within the SDPS components, and among SDPS clients and services.
- Provide interoperability between the EOSDIS Core System (ECS) and the ASTER GDS that allows an EOSDIS user or the ASTER GDS user to view the data holdings and order production data from the other system.
- Provide interoperability between ECS and Version 0 to allow an ECS or Version 0 user to search the data holdings and order data from the other system.
- Provide interoperability between EOSDIS and other systems such as GCDIS or other holdings.

The following sections describe the EGS components assembled to meet these requirements. Figure 3-1 shows the context for EGS, EOSDIS, and EOSDIS components. Section 3.1 describes the SDPS, followed by sections on mission operations, data capture, communications, test systems, and ground stations.

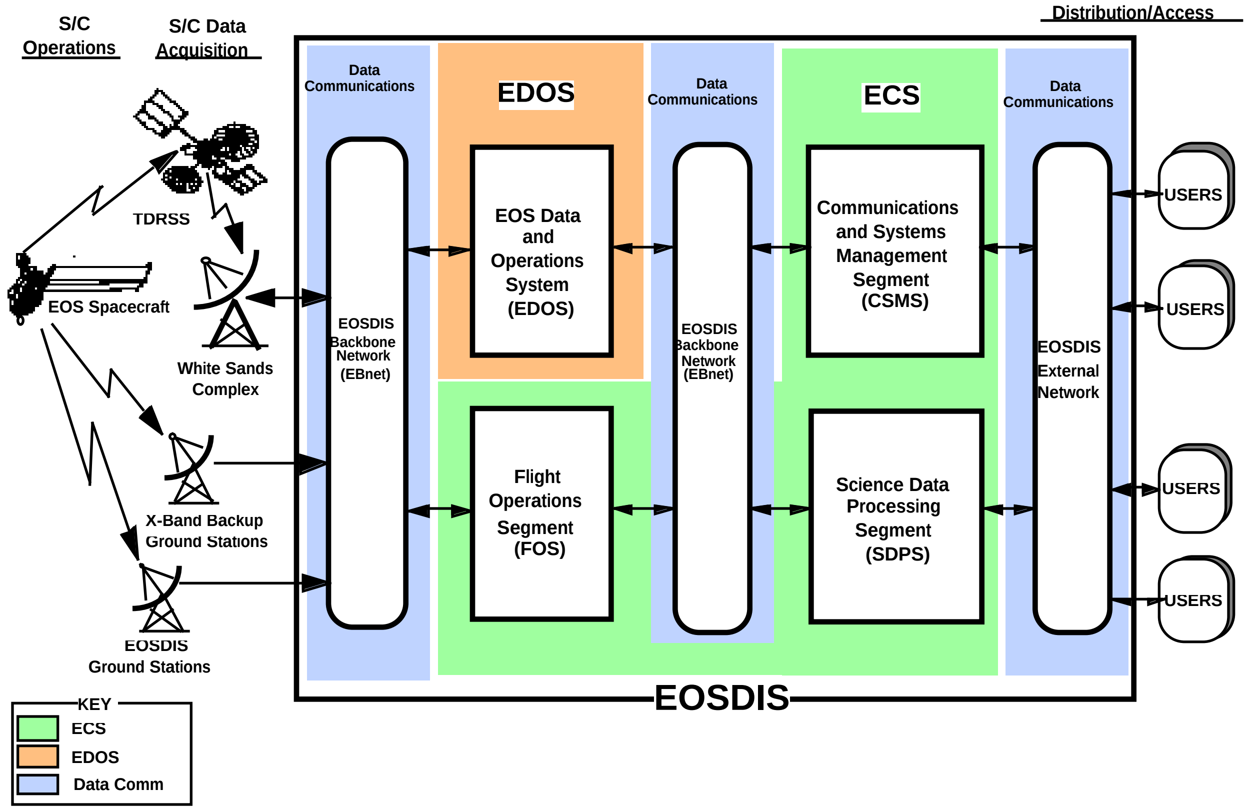

Figure 3-1. Context for EOSDIS in EGS

3.1 Science Data Processing

The distributed network of DAACs is the main EOSDIS institution for performing science operations. The DAACs provide many services, including ingest of Level 0 and ancillary data and products; data management, archive, catalog, and distribution; execution of science software for product generation; user support services; and access, search, and retrieval of EOS and non-EOS NASA Earth science data and all supporting information. DAACs respond to science priorities and guidance and cooperate with other DAACs as integral parts of EOSDIS.

Science data processing and operations may occur at many affiliated and other data centers, universities, and laboratories, in addition to taking place at the DAACs. Although accomplished in a less formal manner, the same approach to implementation of these capabilities is followed: existing Earth science facilities and operations are augmented with EOSDIS tools and components to achieve a broader capability to conduct science operations. In comparison to the DAACs, these other sites typically receive only toolkits or parts of subsystems rather than complete EOSDIS hardware/software systems.

The requirements for the EOSDIS science data processing and operations capabilities were originally expressed in terms of two segments of the ECS implementation contract, as described in Appendix C. These two segments are the CSMS—whose requirements are principally discussed in Sections 3.4 (Data Communications) and 3.5 (System Monitoring and Coordination Center)—and the SDPS, which is addressed in this section. The implementation of these requirements has subsequently followed a functional approach, with the results depicted in Figure 3-2. In this context, the seven configuration items in the middle of Figure 3-2 constitute the SDPS, whereas the management subsystem (MSS) and communications subsystem (CSS) functions at the top and bottom of the figure, respectively, combine to fulfill the CSMS requirement.

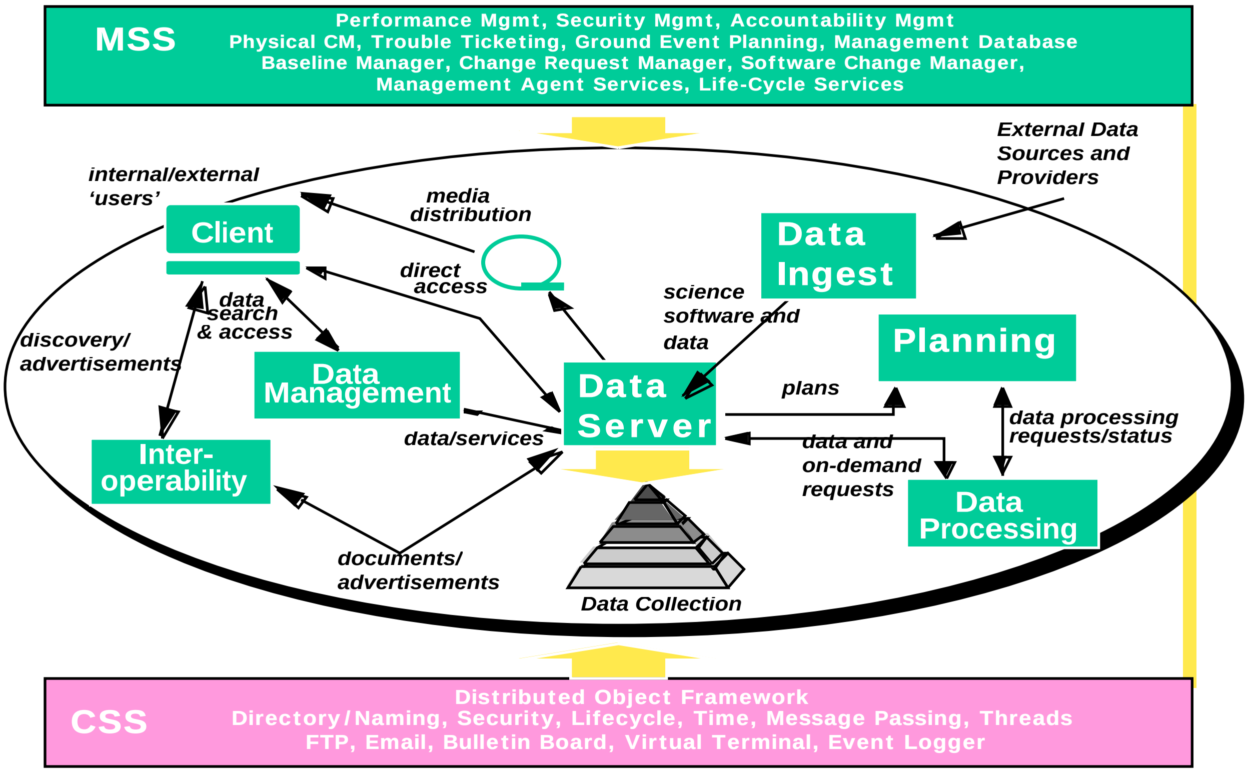

Figure 3-2. EOSDIS Science Data Processing and Operations Context

The SDPS provides a set of data processing and data distribution elements for science data and information systems at the DAACs. The SDPS provides ingest of Level 0 and ancillary data, data management, and archival. The SDPS also provides the processing environment for the execution of science software. The SDPS is the primary user interface to other parts of EOSDIS, providing the science users with the capability to identify and retrieve science data from any of the DAACs. The DAACs themselves provide the facilities for the SDPS functions, along with the management and operations support. The SDPS is designed consistent with the evolving Open Distributed Processing standard.

The SDPS receives, processes, archives, and manages all data from EOS and EOS-related flight missions. It provides support to the user community in accessing the data as well as products resulting from research activities that utilize this data. The SDPS also promotes, through advertisement services, the effective utilization and exchange of data within the user community. It plays a central role in providing the science community with the proper infrastructure for development, experimental usage, and quality checking of new Earth science algorithms.

The SDPS was originally defined as three elements at the requirements level: Product Generation System (PGS), Data Archive and Distribution System (DADS), and Information Management System (IMS). The EOSDIS design and implementation approach allocates these requirements over the seven SDPS and two CSMS configuration items (CIs), with multiple Computer Software Configuration Items (CSCIs) representing a functional approach. These CIs are Planning, Data Processing, Ingest, Data Server, Interoperability, Data Management, and Client subsystems for the SDPS and Systems Management and Communications subsystems for the CSMS. Table 3-1 identifies the involvement of nine subsystems in the three elements. Over time, the use of the logical distinction for PGS and DADS has been greatly reduced, whereas the IMS expression is still frequently used. The following subsections discuss seven CIs of the SDPS.

3.1.1 Planning Subsystem

The Planning subsystem plans and manages the production of standard science products from the EOS telemetry and ancillary data in response to production requests received from users. It is responsible for supporting operation staff in managing the data production activities at a site. Figure 3-3 shows the Planning and Data Processing subsystems in context. The Planning subsystem assists the operations staff in performing two major functions: defining the data processing tasks to be performed at a site and generating efficient plans for scheduling those tasks.

In addition, the Planning subsystem is responsible for coordinating the production with the Data Server and Data Processing subsystems to achieve a highly automated production system.

Table 3-1. Identification of Implementation Subsystems With Original SDPS Elements

Implementation Subsystems	SDPS Elements: Information Management System	Product Generation System	Data Archive and Distribution System
Planning		✶	
Processing		✶	
Ingest		✶	✶
Server	✶	✶	✶
Interoperability	✶		
Data Management	✶		✶
Client	✶		
Systems Management (MSS)	✶	✶	✶
Communications (CSS)	✶		✶

The Planning subsystem obtains, stores, and uses information that is referred to as Product Generation Executive (PGE) Profiles. PGE Profiles include information on the PGE executable, the input data type(s) required, the output data type(s) generated, and the PGE resource requirements—hardware platform, memory, disk storage, etc.

The primary interface of the Planning subsystem with the Data Processing subsystem is to Request (DPR) describes a run of a PGE to the Data Processing subsystem. It describes the specific input granules, output filenames, and run-time parameters for a PGE, as well as dependencies and target run times. The Data Processing subsystem provides status and processing completion information to the Planning subsystem.

The planning user interface provides a means of human interaction with the Planning subsystem. Through this interface, a user can enter production requests. A production request describes an order for data that is to be produced by the Data Processing subsystem. Production requests may signify the need for processing of new data (standard

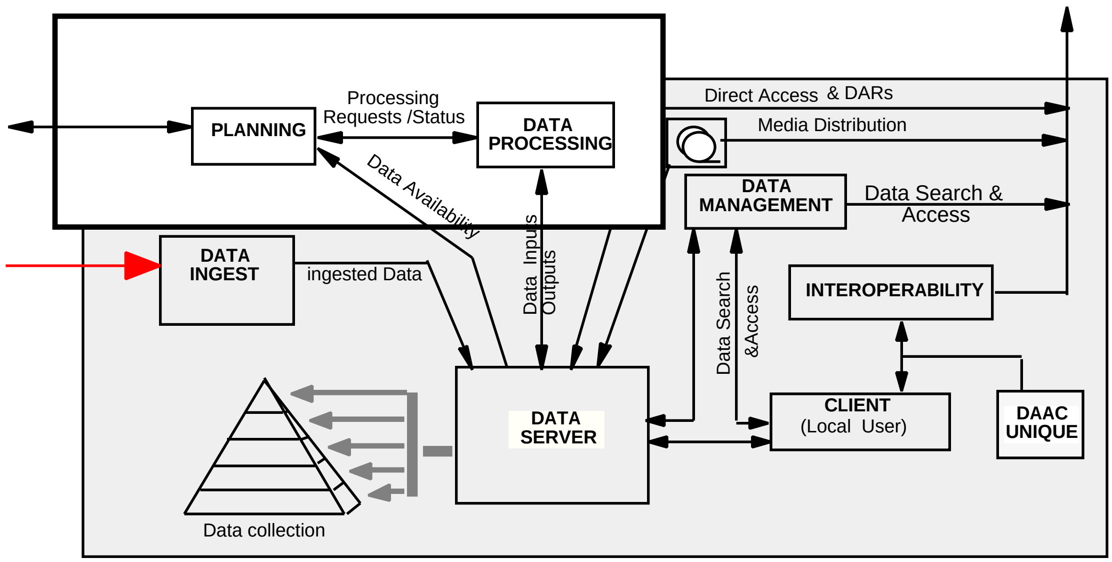

Figure 3-3. Planning and Data Processing Subsystems

production requests, a.k.a. standing orders) or the need for the reprocessing of data (reprocessing production requests). The Planning subsystem takes these production requests and uses the PGE profile information to work out the DPRs that will be required to fulfill the production request. For large reprocessing requests (e.g., 6 months of data), DPRs are generated and ordered on the basis of operator-chosen rules. The planning user interface is also used to issue commands to initiate plan creation, plan activation, and plan cancellation, as well as to provide reports/status of progress within a plan. Additional user interfaces will be provided to inform the system of ground events and external events that can impact processing resources or data. To aid in handling inter-DAAC data dependencies, the planning user interface will also provide the ability to display another DAAC's plan at the local site. The data dependencies between the two sites will be identified by the system.

The Planning subsystem queries the data server holdings for existence of data required for processing. If the data exist, the data server responds with granule information (identification, metadata, and location). The data server also provides the subscription services needed by Planning to determine when new data are available for processing. The operator can use a Planning subsystem utility to generate the subscriptions to be entered into the data server. The data server sends a notification when data that fulfill the subscription are inserted into the data server. Subscriptions are also submitted on data availability schedules and FOS schedules so plans can be based on more accurate predictions of when data will arrive.

In addition, on-demand production requests (ODPRs) are received from the data server. ODPRs are checked against predetermined acceptance criteria as well as resource usage thresholds. If an OPDR fails any of the acceptance criteria, it is rejected, and a notification is made to the requester describing the reason for rejection. If the ODPR is accepted but exceeds a resource usage threshold, it is passed into the regular planning stream and treated as any other standard or reprocessing request. ODPRs that do not exceed the resource usage threshold are sent directly to the Data Processing subsystem.

The Ingest subsystem also provides a subscription service (via the Ingest Data Server) for notification of the arrival of Level 0 data from the Sensor Data Processing Facility (SDPF) and EDOS. The Advertising CSCI within the subsystem provides the advertisement data that is required by the Planning subsystem to generate a subscription.

The Planning subsystem uses the Document Data Server within the Data Server subsystem to store production plans. The Document Data Server then make those plans available to the user community.

The Planning subsystem also has an interface to the systems management subsystem (MSS). The Planning subsystem is responsible for sending MSS fault management data, accounting data, security data, and performance data. The Planning subsystem exchanges mode management information and receives event notifications from the MSS.

3.1.2 Data Processing Subsystem

The Data Processing subsystem generates the science products and provides the processing environment for this function. These responsibilities can be divided into the following general functional areas:

1. Managing the generation of Data Products and the operational environment used to produce these products.
2. Providing an algorithm integration and test environment for the introduction of science software into the EOSDIS environment.
3. Providing a quality assurance (QA) environment for testing the quality of data products.

The Data Processing subsystem supports these functional areas through the following mechanisms:

a. Provides a batch processing environment to support the generation of data products. It manages, queue, and executes DPRs on the processing resources at a provider site. A DPR can be defined as one processing job. Each DPR encapsulates all of the information needed to execute this processing job. DPRs are submitted from the Planning subsystem; which in turn has been triggered by the arrival of data or internally through Planning itself (e.g., reprocessing). DPRs use PGEs to perform this processing. PGEs result from the integration and test of delivered science algorithms and also user-specific methods into the subsystem. PGEs are encapsulated in the ECS environment through the SDP Toolkit. The Data Processing subsystem also provides the operational interfaces needed to monitor the execution of the science software (PGEs).

b. Supports the execution of science algorithms through the SDP Toolkit, which is a set of tools developed to standardize and provide a common interface to the EOSDIS environment for each science algorithm.

c. Supports the preliminary processing of data sets, i.e., Level 0 data products, required to put the science algorithms in the proper format for use.

d. Provides the algorithm integration and test environment used to integrate new science algorithms, new versions of existing science algorithms, and user methods into the EOSDIS environment. The algorithm or method is acquired by the system through an ingest client, which reflects local site policies on the acceptance of software for integration. Once acquired, the algorithm/method and its associated data files (test, calibration, etc.) are registered in the local site configuration management (CM) system as part of the archival by the Data Server subsystem.

e. Provides the DAAC QA environment that DAAC personnel use to validate data products. All data products, those both produced by and input to a submitted job, can be examined by DAAC personal to verify that their content meets quality standards.

The following paragraphs describe the key interfaces for the Data Processing subsystem.

a. The Planning interface is responsible for determining what processing activities are required to generate the data products as specified in a standard production request. These processing activities and associated information are defined and delivered as DPRs to the Data Processing subsystem. One production request may result in one or more DPRs being sent to the Data Processing subsystem. After the receipt of a DPR, the Data Processing subsystem delivers processing status to Planning when requested. The Data Processing subsystem also provides an unrelated offline activity, information used to plan the execution of a PGE. This information is determined by the Algorithm Integration and Test services and is provided to Planning through the adding of data to the SDPS Database.

b. The data server interface is for requesting access to data required as an input to a PGE and for requesting that generated output data be transferred to the data server. The data server is also used to archive PGEs and associated data that require staging.

c. The Ingest interface is for requesting access to Level 0 data to be preprocessed before being input to a PGE.

d. The MSS/local system management (LSM) interface provides access to common ECS system management services and application programming interfaces (APIs) to pass accounting and CM information.

3.1.3 Data Ingest Subsystem

The Data Ingest subsystem contains a collection of hardware and software that supports the ingest of data into ECS repositories on a routine and ad hoc basis and triggers subsequent archiving and/or processing of the data. Figure 3-4 shows the Data Ingest and Data Server subsystems in context. The Ingest subsystem configuration must be flexible to support a variety of data formats and structures, external interfaces, and ad hoc ingest tasks. Data processing and storage functions to be performed by the Ingest subsystem and ingest clients vary according to attributes of the ingested data such as data type, data format, and the level to which the ingested data has been processed.

From a software perspective, the Ingest subsystem is organized into a collection of tools from which those required for a specific situation can be configured. The resultant configuration is called an ingest client. Ingest clients may exist in a static configuration to service a routine external interface, or they may be specially configured and exist only for the duration of a specific ad hoc ingest task. The ingest clients provide a single virtual interface point for the receipt of all external data to be archived within the SDPS. Individual ingest clients are established to support each unique interface, allowing the interface parameters to be modified as interface and mission requirements evolve. The ingest clients perform ingest data preprocessing, metadata validation, and metadata extraction on any incoming data as required.

Data is staged to one of two areas depending on the data level, data type, and other data set specific characteristics, as follows:

- Level 0 data from ongoing missions is staged to the Ingest subsystem working storage area, where the data is ingested and stored in the Level 0 rolling store. The staged data is also accessible by the SDPS Processing subsystem for that data that must be processed to higher levels.
- Level 1a-4 data is staged directly to the working storage area in the Data Server subsystem. Ingest client functionality such as quality checking and reading of metadata is performed on these data on the Data Server subsystem processor hardware. The data server then archives the data in the logical and physical data server to which the particular data has been assigned.

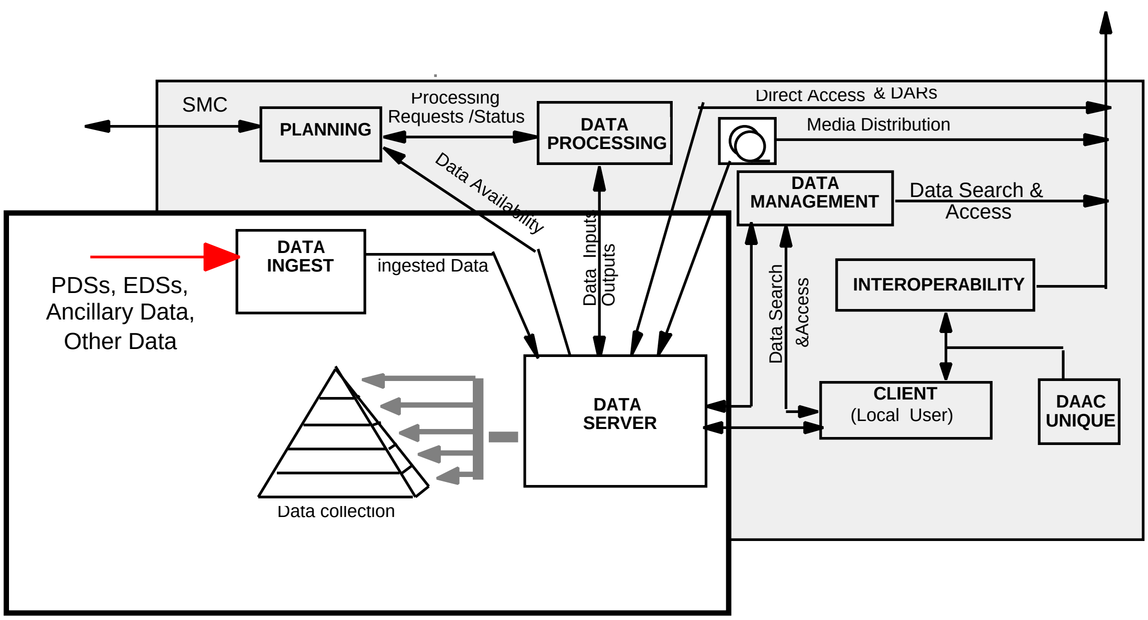

Figure 3-4. Data Ingest and Data Server Subsystems

The hardware components of the Ingest subsystem are similar to those of the Data Server subsystem but are specialized to meet the ingest requirements at a given site. Specialized forms of ingest clients may be incorporated into site-unique architectures, and additional processing hardware may also be incorporated at those sites where special transformations must be accomplished on ingest data sets.

The Ingest subsystem must be capable of accepting data from a variety of sources, including both electronic network interfaces and hard media. Early interface testing is performed at Interim Release-1 (IR-1) for interfaces at the SDPF, TSDIS, and the NOAA ADC. Early interface testing is performed at Release B0 for the EDOS, Landsat-7, and EOC interfaces. Release B1 interfaces include the SDPF, TSDIS, NOAA ADC, the SCFs (for algorithm delivery), the Data Server subsystem (for archiving), science users, clients (operations staff), Version 0 DAACs, and other DAACs. Early interface testing is performed at Release B for EDOS, the Landsat Processing System (LPS), and EOC interfaces. The EDOS, LPS, and EOC interfaces are fully functional at Release B. Interfaces are added at Release B for the Landsat IGSs and Image Assessment System (IAS), ASTER GDS, Release B SCFs, Flight Dynamics Facility (FDF), SeaWinds, SAGE III, ALT/RADAR, ACRIM, and DAAC-unique interfaces (including ERS, JERS, and RADARSAT at the Alaska SAR Facility [ASF]). Additional interfaces are planned to be implemented in future releases.

The following assumptions have been made regarding the characteristics of the data to be ingested:

- EDOS, the spacecraft data capture and distribution system discussed in Section 3.3, and SDPF (which is a NASA institutional system used for data capture for the TRMM mission) each generate production data sets (PDSs), which are transferred when the data set is complete. EDOS has stated that PDSs will be based on time and/or size (not granule or orbit). Each transferred file contains only one Application Process ID (APID). SDPF has stated that the data will be transferred once per 24-hour period.

- Receipt and processing of products from other sources is assumed to be random but largely continuous over a 24-hour period. Ingest subsystem resources are sized to handle predictable peak loads.

Main drivers for the Ingest subsystem design are

- The high reliability required for Level 0 data ingest

- The required extensibility of the ingest client implementation to future external interfaces

- The demands imposed on ingest by the migration of Version 0 data from DAAC repositories external to ECS

The Ingest subsystem design incorporates the measures described in the following in response to the above drivers.

1. The need for high reliability to support the function of Level 0 science data ingest was resolved by the logical and physical separation of the Ingest subsystem (Level 0) data server from the other data servers. The ingest of Level 0 data has a very high priority and must be

supported with high component reliability and availability. Maintaining this level of reliability, maintainability, and availability (RMA) throughout the entire SDPS would be prohibitively expensive. Separating a high RMA ingest complement of hardware and software from other SDPS functions allows each subsystem within SDPS to support only the level of RMA necessary to perform its required functions.

2. The need for future extensibility was resolved by separating the ingest processing component from the associated data server component and providing template interface software that may be reused as new interfaces are added or old interfaces are modified. The external interfaces to be supported by the ingest clients change over time as spacecraft and instruments are added and removed. Each external interface must potentially be supported with a different data transfer mechanism, format conversion, quality checking, metadata definition, and other attributes unique to that data. Separating the performance of these functions from the Level 0 data repository component minimizes or eliminates changes to the data server configuration as mission requirements change.

3. In addition, each new or modified external interface may require custom interface software to facilitate the data transfer process. The long-term EOS program expects to add large numbers of new interfaces over time. The Ingest subsystem software is designed in a modular fashion to minimize the development effort required for new or modified interfaces.

4. The volume and complexity of data provided from the Version 0 facilities to the ECS for archival are critical design drivers for the ECS Ingest subsystem. Over 600 data products have been identified, ranging in volume from megabytes to hundreds of gigabytes. Total volume is on the order of dozens of terabytes. Many of the data products are stored in some form of Hierarchical Data Format (HDF); however, many more products are stored in other formats. The Ingest subsystem software is designed to generalize the mechanism by which data is routinely stored within the SDPS, given a set of standalone tools used to prepare Version 0 data. Version 0 "data preparation" includes retrieval from Version 0 specific hard media; conversion to EOS-HDF, where required; and extraction of standard metadata.

3.1.4 Data Server Subsystem

This subsystem is responsible for storing Earth science and related data in a persistent fashion, providing data repositories and management capabilities necessary to safely store data on a permanent basis. The subsystem stages data the Data Processing Subsystem needs for data processing. It organizes and stores its data by data types and provides advanced search capabilities and processing services on those data types. It supports the administration of the data and the supporting hardware devices and software products. As part of its retrieval function, the subsystem also provides for the distribution of data electronically or on physical media. Characteristics of the Data Server subsystem are as follows:

- Provides advertisements for data types and corresponding data type services to the Interoperability Subsystem.
- Stores data received through ingest by the Ingest Subsystem or resulting from processing in the Data Processing Subsystem, as well as historic data from FOS.

- Issues production requests into the Planning Subsystem and acquisition requests into a DAR processing subsystem as a result of data requests issued by data server clients. It also supports the Planning Subsystem by storing data availability schedules.
- Accepts data search and access requests from any subsystem or other segment provided that they are directed specifically at the data objects managed by the given instance of the Data Server subsystem. (All other search and access requests are funneled through the distribution information manager (DIM) and/or local information manager (LIM) services of the Data Management subsystem.)
- Provides the data resulting from these access requests through electronic transfer or on physical media. The subsystem can also provide references to this data in the Universal Reference format instead.
- Provides subsystem events, status, and management information to the System Management Subsystem and receives management directives from there.
- Interfaces with MSS/LSM and the System Monitoring and Coordination Center (SMC) to provide subsystem status and log information.
- Interfaces with CSS-provided security services to authorize clients.

The Science Data Server portion of the Data Server is responsible for managing collections of Earth science and related data and for servicing requests for the storage, search, retrieval, and manipulation of data within those collections. The Document Data Server manages electronic documents and associated metadata. It supports the browsing and searching of document data types via the World Wide Web. Both of these servers manage interactive sessions with external clients, provide advertisements to the Interoperability Subsystem to announce the availability of data and services to external clients, and work with other subsystems to “insert” data and documents for storage and access.

The Storage Management portion of the Data Server provides management services for file systems, storage devices, ands media peripherals in support of the Data Server, Ingest, and Data Processing Subsystems. It supports a data referencing capability based on the use of unique file names that do not change even if the location of the data changes within the managed resources. Storage Management supports the establishment of operational priorities and the allocation of storage resources on the basis of user priority.

The Data Distribution portion of the Data Server is responsible for formatting and distributing data to users. Data is distributed either electronically or by means of physical media.

3.1.5 Client Subsystem

The client subsystem provides a collection of components through which users access the services and data available in ECS and other systems interoperable with ECS. Figure 3-5 shows the Client, Interoperability, and Data Management subsystems in context.

A primary role of this subsystem is to give the users efficient access to the ECS data products, providing them with all the information and tools to search, locate, select, and order products required to perform their science investigations. These products may be stored in the archives or may entail higher level processing of an archived product or placing an acquisition and processing request. The subsystem also assists the users in locating and ordering non-ECS data from ADCs and other cooperating data centers.

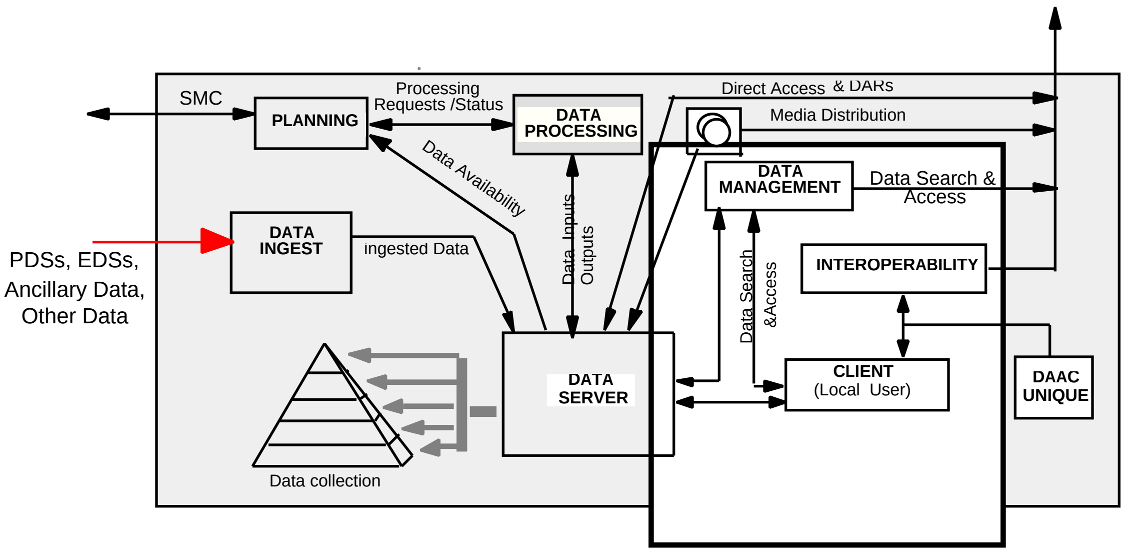

Figure 3-5. Client, Interoperability, and Data Management Subsystem

The Client Subsystem was initially going to be developed as an X-client application that could run native on any UNIX machine or through front ends like Mac-X on Macs and PCs. Java technology, which was just a rumor at the beginning of the project, has developed so fast that this technology will be used to support the science users. Java Earth Science Tool (JEST) will be developed and should provide easy universal access. Java browsers are becoming commonplace, and supporting applications are becoming efficient and cost effective. The Java environment will host a set of tools that allow a user to

- Open an account
- Use help functions
- Search for science data
- Search for related science and software documents
- Browse examples of the identified data
- Order the desired data
- Request status of searches and orders
- Interface with the ASTER System

The following subsections list these tools and describe the functions they perform.

3.1.5.1 Open Account

Home Page

- Support links to registration and login, access to Advertising Service, and other support capabilities (such as basic overview, help and tool descriptions, etc.)

Authentication/Authorization

- Login screen
- Pass user ID, password to IDG authentication service
- Incorporation of user ID with requests in support of access control lists (ACLs)
- Guest user support

MSS Interfaces

- User registration request
- User profile update or access request
- User registration request
- Credit check request

3.1.5.2 Use Help Functions

Help/Training Tool

- General help for tools
- Tutorials for tools
- User’s guide
- Context sensitive help

3.1.5.3 Search for Science Data

Basic Search

- Support inventory query; includes shipping of inspectable attributes with query
- Graphical user interface (GUI) design based on folders concept
- Support display of relationship between selected level of search and attributes
- Explicit selection of search logic in inventory search GUI

Attribute Selection

- Interface to DDICT to retrieve attributes
- Management of search, results, and ordered list of attributes through attribute selection tool
- Management of default grouping of attributes through attribute selection tool
- Selectable and writeable user preference for default list of attributes for search, results, and order through attribute selection tool

Dependent Valids Display and Selection

- Interface with DDICT to calculate/retrieve dependent valids for all attribute valids
- Cache dependent valids at Client
- Display dependent valids relationships between attributes, including spatial and temporal as user selects valid values.

Map and Timeline Display

Map

- Support graphic overlays (political and coastal boundaries and bathymetry)

- Support multiple projections (lat/long, north and south polar)
- Support display of grid
- Support text input of grid points
- Support input of path/row for swath search
- Design of user interface to be consistent with common dialog design.
  Geographic name searching

Timeline
- Enhanced starfield display
- Support for metadata inspection with new tools
- Design of user interface to be consistent with common dialog design
- Support for B0 collections
- Support for text input
- Support for periodic selection of temporal ranges
- Allow multiple range selection
- Event name searching
- Inclusion/exclusion of range
- Periodic selection

Product-Specific Attribute Searches
- Full product-specific attribute searches

Metadata Exceptions
- Display of collection hits based on attribute context
- User can indicate whether or not to except
  - ⇒ attributes that are not defined for a given collection
  - ⇒ attributes that are defined but have no values for a specific instance

Research Planning Assistance
Coincident Search Features
Incremental Search Features

Search Results Display
- Display advertising and inventory results
- Results GUI to include table paradigm with full column management (reorder, collapsible, etc.)
- Support re-sort and re-group
- Support filtering
- Support working list concept (type of filter)
- Allow customization of attribute set
- Allow customization of number of granules loaded into table by default
- Allow the user to get the “next” number of granules
- Return the granules aggregated (grouped) by collection by default; allow the default to be selectable; return the results with the collection presented as a single row indicating the presence of granules within
- Granule coverage by temporal and spatial locality

Subselection (spatial and temporal):
- GUI based on common dialog design
- Spatial, temporal, and parameter-based subsetting
- Subsetting by pixels or path/row
- Subsampling by pixels or path/row
- Averaging by bins of pixels or path/row

V0 Interface
- Search requests (including specification of the attributes to be returned)
- Service requests (browse, subset)
- Acquire requests
- Price estimate request
- Service requests (on-demand processing)
-

Advertising Service Interface
- Search request
- Signature service requests for services and media on collections
- Signature service request for ODPR parameters

ESQL Interface for Expert Query Formulation

Assess the Quality of the Identified Data

Data Server Interface
- Search requests (including specification of the attributes to be returned)
- Service requests (browse, subset)
- Acquire requests
- Price estimate requests
- Service requests (on-demand processing)

3.1.5.4 Search for Related Science and Software Documents

Basic Search

- Support advertising query (search for advertisements of EOSDIS data and other systems)
- Support DDICT query (for definitions of science terms and aliases)
    - ⇒ Request for attributes and valids
    - ⇒ Request for dependent valids
    - ⇒ Requests for definitions
- Guide search covers searches for documents about instruments, data types, algorithms etc.

3.1.5.5 Browse Examples of Identified Data

Browse (Integrated) Service
- New GUI based on common dialog design
- Browse HDF file structures, including images, tables, and associated metadata
- Allow deletion of represented granule from results list
- Allow ordering of represented granule from results list
- Allow access to, or show with, coverage of browse granule
- Allow access to other services (such as subsetting)

3.1.5.6 Order Desired Data

Product Request Tool
- GUI based on table design used in results display
- Attribute selection
- Access to user profile information for order
- Manipulation of collections/granules (sort, group, etc., as with results)
- Support media selection
- Support Landsat-7 billing and accounting workaround
- Granule versioning support
- Price/time estimates

- Granule level order tracking
- Order segmentation support
- Request partitioning

Subscriptions

- Allows user to subscribe to regularly produced products

3.1.5.7 Request status of searches and orders

Search and Service Request Status
- Search status from data servers
- Search status from LIM/DIM
- Status single search request (as opposed to all of the child requests when searches are submitted to LIM/DIM)
- Status reasons for search failure/partial search
- Same status on service requests such as browse

3.1.5.8 Interface with ASTER System

ASTER DPR

- Support for ordering higher level (ASTER Level 2) product given default ODPR parameters

ASTER DAR Status (Web and X/Motif)

ASTER DPR (Web)

- Support for ASTER higher-level products (user-defined parameters)

3.1.6 Interoperability Subsystem

The Interoperability subsystem provides advertisements about both ECS and non-ECS services, providers, and data.

- The subsystem accepts advertisements, subscriptions, and search requests from the Client subsystem.

- The subsystem accepts search requests from the Ingest, Planning, and Processing subsystems.

- The subsystem also accepts advertisements and subscriptions from the Data Server and Data Management subsystems.

- The subsystem also receives advertisement and subscriptions from non-ECS service providers such as International Partners (IPs), SCFs, and ADCs.

- The Interoperability subsystem receives life-cycle commands and mode requests from the MSS and logs events with the MSS.

3.1.7 Data Management Subsystem

The Data Management subsystem provides services that search for, locate, and access data on behalf of a user or another program. Data Management services decouple users and programs from the methods a site uses to access the data and from the manner in which the data have been named. This subsystem contains four parts, as follows:

- The data dictionary service manages the definitions of data objects; attributes; domains (valid values); and access operations available via science data servers, local information managers, and distributed information managers. The information is stored in a relational database management system. The database is replicated at each DAAC using the COTS database management system (DBMS) software to perform the replication.
- LIMs provide access to data and services at a site to the extent that the underlying data servers make their data available via this manager. The LIM accepts requests, such as a search, and produces and executes the corresponding requests that must occur at the data servers for that site. An operator must specify to the manager what objects can be accessed at the various data servers at a site. A site can modify the manager to provide site-specific access to other data sources besides data servers.
- The DIM provides access to data and services across sites. It accepts requests, such as a search, and produces and executes the corresponding requests that must occur at the LIMs and/or data servers.
- The Version 0 Gateway (GTWAY) provides interoperability services between the ECS data server and the Version 0 client.

Drivers for the design of the Data Management subsystem are as follows:

- Decouple users and programs from the methods used by sites to access the data and the way the data are named
- Provide interoperability between the Version 0 client and the ECS data server
- Simplify data administration
- Provide site autonomy
- Provide interoperability between the ECS Workbench and the Version 0 Client servers
- Provide services for the ECS Workbench to execute distributed queries, i.e., queries that access multiple sites and possibly correlate results between sites
- Provide services for the ECS Workbench to execute queries that access multiple data servers within one site and possibly correlate results between data servers

3.2 Mission Operations

The EOC manages and controls the EOS spacecraft and instruments. The EOC is responsible for mission planning, scheduling, control, monitoring, and analysis in support of mission operations for the U.S. EOS spacecraft and instruments. The Instrument Support Terminal (IST) at the investigator site connects the PI or TL facility to the EOC in remote support of instrument monitoring and command planning. The IST Toolkit (see section 3.2.2) is a software capability that integrates with the EOC for seamless operation.

3.2.1 EOS Operations Center

There is one EOC at GSFC that is responsible for coordinating the operations of all EOS instruments, U.S. or IP, for the U.S. spacecraft in addition to the operations of the U.S. spacecraft. The EOC plans and schedules all EOS spacecraft system resources and assembles and generates conflict-free instrument schedules on the basis of preplanned management information received from the NCC, EDOS, FDD, and spacecraft analysis. The EOC merges and validates instrument software loads and command data. The EOC also provides capabilities to forward commands in real time or store them for later transmission. It validates instrument command sequences before transfer to EDOS for uplink to spacecraft. In addition, the EOC provides limit monitoring of spacecraft and instrument parameters and develops contingency plans for use during spacecraft anomalies. Figure 3-6 is a functional block diagram of the EOC.

3.2.1.1 Conceptual EOC Architecture

The EOC design is made up of nine loosely coupled functional subsystems called services (See Figure 3-6). A key requirement of the EOC architecture is to ensure that it is designed to be scaleable and extensible to support multiple spacecraft simultaneously in varying states of development, testing, and operations. The challenge in fulfilling this requirement is that the system will evolve over a period of years before the full complement of spacecraft will be designed. Thus, the primary feature of the EOC system is an evolvable architecture that facilitates reduced life cycle costs. This is accomplished through the following characteristics:

1) A single EOC that can support multiple missions concurrently. The use of logical strings provides operational flexibility. A logical string is a collection of hardware and software resources and information about how these resources are being used to provide spacecraft and instrument control and monitoring during real-time contacts, simulations, and historical replays. A unique logical string exists for each real-time scenario (i.e., contact, simulation, and historical replay). Logical strings enable an operator to monitor data from multiple sources on the same display, allowing simultaneous support to multiple spacecraft.

2) EOC functions implemented by building blocks, allowing reuse of blocks for future missions. New software will focus on mission customization requirements.

3) Development of a database-driven system to facilitate ability to add, modify, and adapt functions.

4) Hardware implementation that is platform independent.

5) Streamlined operational tasks and an automation framework to facilitate increased automation.

3.2.1.2 EOC Functional Requirements

The combination of all nine EOC services provides for normal operations as well as accommodating changes for emergencies and contingencies, including Targets of Opportunity (TOOs). TOOs are defined from a EOC point of view as late changes to schedules to accommodate science requests. The following paragraphs describe these services.

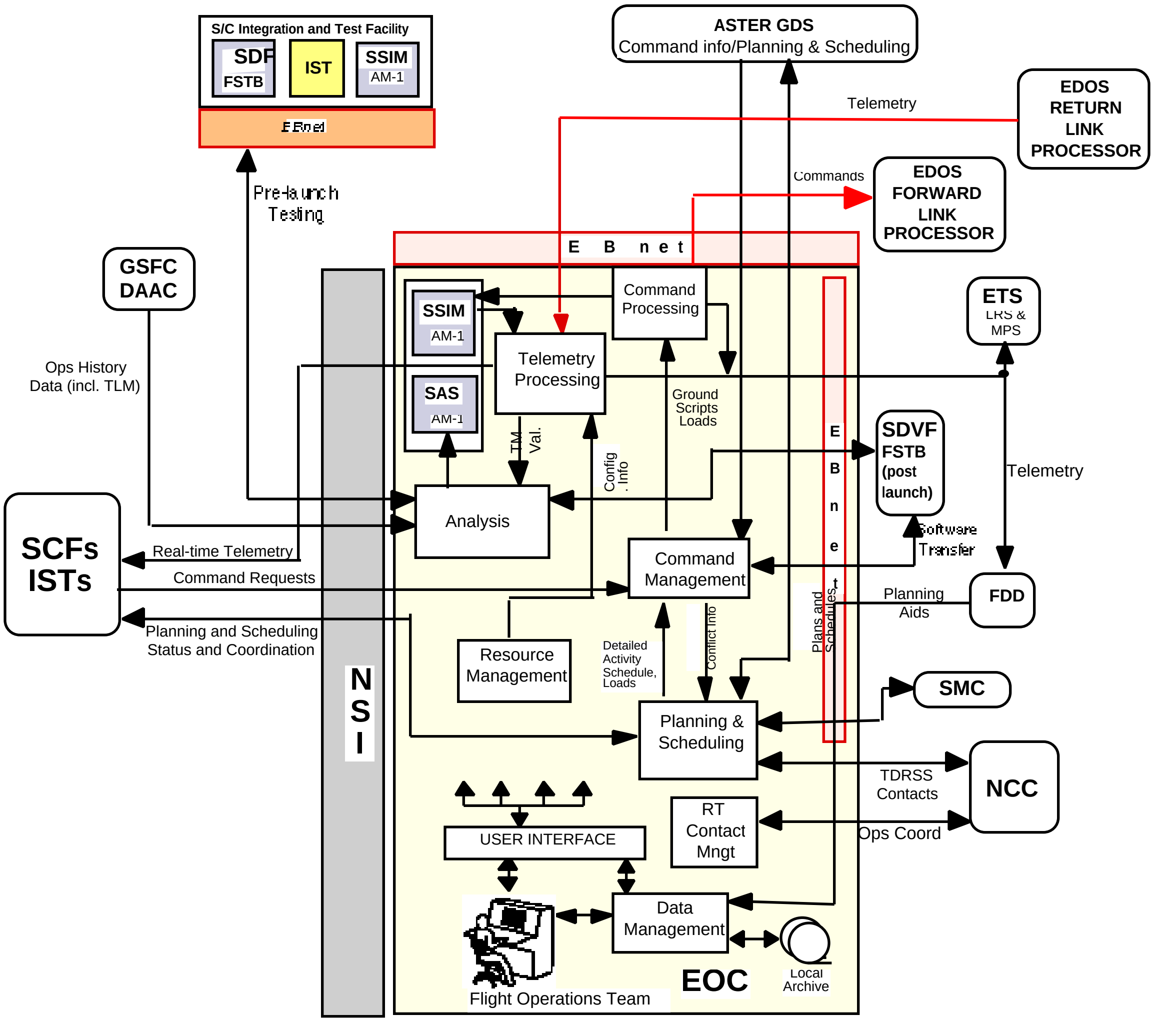

Figure 3-6. EOC Functional Diagram

3.2.1.2.1 Planning and Scheduling Service

The Planning and Scheduling Service (P&S) generates the integrated plans and schedules for spacecraft and instrument operations. These plans and schedules are dependent upon instrument science activities, instrument support activities, and spacecraft subsystem activities. As part of the Planning and Scheduling Service, the Project Scientist at the EOC may be requested to resolve instrument scheduling conflicts while ensuring that EOS

mission science objectives are met. The EOC reintroduces applicable requested activities into its planning and scheduling function when the activity does not occur because of a deviation from the schedule. Plans and schedules are provided to the SDPS as user information.

The Long Term Science Plan (LTSP) is generated by the Investigator Working Group (IWG) and contains guidelines, policy, and priorities. It is generated/updated every 6 months and covers a 5-year period. The Long Term Instrument Plan (LTIP) is also generated/updated by the IWG for the same period and provides instrument-specific information. The instrument resource profile is generated/updated weekly, covering a target week, and is produced several weeks in advance. It is based on instrument science activities, instrument support activities, the previous instrument resource profile, the long-term science and instrument plans, and resource availability and guidelines from the EOC. The EOC integrates the instrument resource profiles with its spacecraft subsystem resource profile, producing the preliminary schedule. A detailed activity schedule is generated daily, covering the next several days. The detailed activity schedule can be modified for a TOO up to 24 hours before an observation. A TOO requiring no schedule changes can be accepted up to 6 hours before the observation. A TOO that requires only real-time commands can be accepted 1 hour before the next station contact. Figure 3-7 summarizes the planning and scheduling activity.

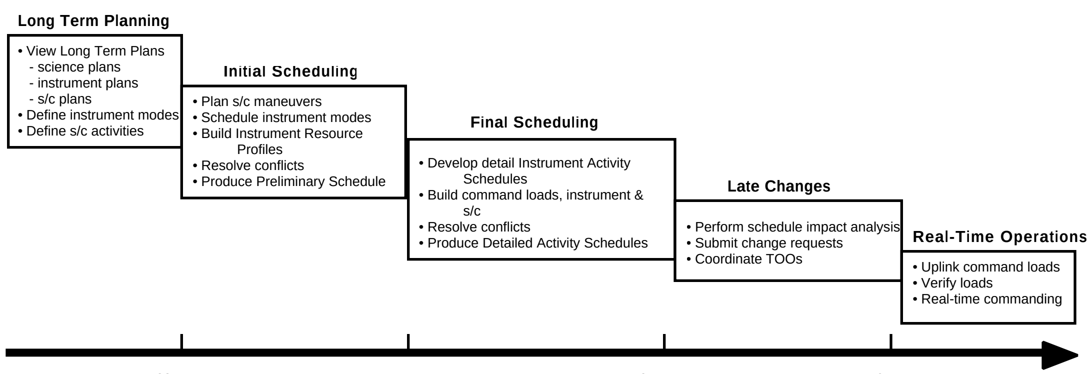

Figure 3-7. Planning and Scheduling

The EOC receives from the FDD predicted orbit data, including predicted ground track information and predicted maneuver times for scheduling. The EOC manages spacecraft resources that are not managed onboard, including scheduling the spacecraft recorders and communications subsystems.

3.2.1.2.2 Command Management Service

The Command Management Service provides management of preplanned uplink data for the EOS spacecraft and EOS instruments primarily on the basis of the detailed activity schedule. The Command Management Service accepts SCC-stored instrument commands, SCC-stored instrument tables, and instrument microprocessor memory loads and validates them for appropriateness, checking for authorized sources and for violation of selected constraints. It integrates the SCC-stored spacecraft and instrument commands in preparation for uplink, manages spacecraft computer stored command memory, packages commands for onboard storage, and produces a memory map for the spacecraft stored command processor. The service also provides high-level validation for preplanned command groups, which are stored on the ground in preparation for real-time execution.

3.2.1.2.3 Commanding Service

The Commanding Service in the EOC will provide the capability to transmit uplink data to the EOS spacecraft and instruments via EDOS. Uplink data are made available to the EOC Commanding Service by the EOC operators or the EOC Command Management Service.

The EOC operators will require that real-time spacecraft and instrument commands be constructed and uplinked in real time during contacts with the spacecraft. The EOC Commanding Service performs the processing necessary for this function. In this category, commands are either entered directly by the operator or generated from either a real-time or preplanned command group. (A command group is a logical set of commands. A preplanned command group is one that has been preprocessed by the Command Management Service and stored on the ground for later uplink, whereas a real-time command group has not undergone any preprocessing.)

3.2.1.2.4 Telemetry Processing Service

The Telemetry Processing Service provides the capability to receive and process both real-time and spacecraft recorder housekeeping data from the EOS spacecraft and instruments. This housekeeping data will be downlinked from the spacecraft and instrument in Consultative Committee for Space Data Systems (CCSDS) packets. EDOS will transfer the packets to the EOC.

When receiving real-time housekeeping telemetry, the Telemetry Processing Service decommutates the contents of the packets, performing the necessary conversions and calibration and determining values for other derived parameters. Various forms of limit checking are performed on the housekeeping parameters, including boundary limit checking on nondiscrete parameters, delta limit checking (examining the difference between successive parameter sample), and rail limit checking (checking for saturated parameter values). For each parameter being checked for boundary limits, the Telemetry Processing Service uses one of several limit sets, in which each limit set consists of definition for one or more upper and lower boundaries for the parameter. (These are commonly referred to as red/yellow, high/low limit sets.) All parameters, along with associated limits, quality, and event information, are made available to the operator of the User Interface Service. The Telemetry Processing Service also extracts a subset of the real-time telemetry stream for transfer to the FDF and the ISTs.

3.2.1.2.5 Spacecraft Analysis Service

The Spacecraft Analysis Service provides the EOC operators the capabilities needed to perform spacecraft systems management, performance analysis, trend analysis, CM, and resource management. These functions are provided on a noninterference basis with real-time telemetry processing functions. A subset of these functions is provided in real time. The spacecraft analysis service also supports fault detection and isolation.

The EOS evaluates the performance of the spacecraft core systems and the status of instruments. Performance data are processed from spacecraft recorder housekeeping data, history files, and real-time housekeeping data. The EOC reports on the quality of the data used for the analysis, reports failures detected, and identifies marginal system operation. The EOC enables operators to analyze the performance of the power, command and data handling, thermal, communications, and guidance navigation and control subsystems.

3.2.1.2.6 Data Management Service

The EOC Data Management Service generates and maintains a Project Data Base (PDB) and a history log. The PDB contains descriptions of all spacecraft housekeeping data formats, housekeeping parameter descriptions, command formats, display formats, and operator directives needed to evaluate the health and safety of the spacecraft and instruments. The history log is used for maintaining the records of all spacecraft and instrument operations activities. It includes commands sent to the spacecraft and instruments, telemetry data received, NCC messages sent and received, operator directives, element manager directives, a SCC ground reference image, and event and alarm messages.

3.2.1.2.7 Resource Management Service

The EOC Resource Management Service has capabilities to schedule EOC activities, manage the configuration of the EOC hardware and software, control and monitor the configuration of its components, monitor performance, manage operator and remote system access information, generate reports, and provide operations testing. It coordinates operations with EDOS and the SMC.

3.2.1.2.8 User Interface Service

The User Interface Service in the EOC provides authorized EOC personnel with access to every function, including planning and scheduling, control and monitoring, and analysis and management of the spacecraft, instruments, and the EOC itself. This User Interface Service consists of two main capabilities: a set of mechanisms through which the operator can specify actions to be taken by the system and provide responses and input and a display function through which the user can monitor the spacecraft, instruments, the EOC components, and the results of user requests.

3.2.1.2.9 Real-time Contact Manager

The Real-time Contact Manager is responsible for receiving periodic status information from EDOS and the Network Control Center (NCC) during real-time contacts with EOS spacecraft. This status information includes monitor blocks and operation messages. In addition, the Real-time Contact Manager can send ground configuration messages to the NCC during a real-time contact.

3.2.1.3 EOC Interfaces

The primary EOC interfaces are defined as follows:

DAAC: The EOC provides the GSFC DAAC with spacecraft status information and historical data about EOS mission operation for archiving. The EOC receives from the GSFC DAAC storage status that indicates the success or failure of storage of the data the EOC sends to the DAAC.

EDOS: The EOC provides spacecraft and instrument uplink data to EDOS. EDOS provides CCSDS packets containing real-time or spacecraft recorder and instrument housekeeping data, spacecraft and instrument command status data, and spacecraft processor memory dump data to the EOC. The EOC and EDOS exchange accounting, fault coordination, data operations status, and planning information. The EOC interfaces with EDOS to request changes in data delivery services and to make inquiries into data delivery status. EDOS provides the EOC with the data delivery service status.

FDD: The EOC receives from the FDD predicted orbit data, including predicted ground track for scheduling. The EOC also receives from the FDD contact availability times, uplink table data, and other planning products. The FDD develops plans for spacecraft maneuvers. The EOC receives, schedules, and implement these plans. The EOC provides telemetry to FDD-provided attitude support equipment collocated in the EOC for determining spacecraft attitude and to an IST located on the FDD workstations.

SDPS: The EOC sends copies of acquisition plans and schedules to the SDPS during its planning and scheduling activities to provide the user with information. The EOC provides the SDPS with spacecraft information used in DAR generation, including orbit data.

IP instrument control center (ICC): The EOC exchanges planning and scheduling information with the IP ICC, sends mission status to the IP ICC, and receives instrument commands and status from the IP ICC.

IST: In its role as mission coordinator, the EOC exchanges instrument planning and scheduling information with the instrument team ISTs, complying with the concept of global access to planning and scheduling information. In response to the scheduling process, the ISTs generate instrument uplink data consisting of SCC-stored commands, SCC-stored tables, and instrument microprocessor loads that implement the scheduled observations. The EOC accepts instrument uplink data from the ISTs, validates them at a high level, and integrates them. The instrument team is responsible for the contents of its instrument microprocessor loads. In its role as overseer of mission operations, the EOC receives instrument status information from the ISTs to perform high-level monitoring.

NCC: The EOC receives from the NCC forecast and active schedules of ground station and TDRSS contacts. The EOC transmits schedule requests for ground station start times and duration to the NCC. The EOC and the NCC exchange messages that include status and resource reconfiguration information.

SMC: Via the SMC, the EOC receives EOS management and operation directives, including science policy and guidelines from the IWG plan, contained in the LTSP and LTIP. The EOC returns EOC management and operations status.

Spacecraft Simulator (SSIM) and Software Development and Validation Facility (SDVF): The EOC receives flight software updates for uplink to the spacecraft from the SDVF. For training and simulation, the EOC sends spacecraft and instrument commands and simulator directives to the spacecraft simulator. The spacecraft simulators send telemetry data and simulator responses to the EOC. The spacecraft simulators fulfill the purpose of flight operator training, validation of operational procedures, and anomaly resolution.

The Spacecraft Analysis Software (SAS) developed by the Spacecraft Contractor for the AM-1 Mission is collocated at the EOC for the use of the Flight Operations Team (FOT) in analyzing spacecraft performance in addition to the capabilities provided by the ECS Spacecraft Analysis Service. To facilitate this use, an interface is provided between the two analysis capabilities.

Located in the EOC are the EOS Polar Ground Network (EPGN) monitor capabilities to allow coordination of interoperation of the EOC with the high latitude ground stations via the Wallops Flight Facility (WFF).

3.2.2 Instrument Support Toolkit

An Instrument Support Toolkit (IST) is a collection of software executable programs that support remote participation by ECS instrument teams in the scheduling, monitoring and analysis of their instruments. This toolkit running at a workstation constitutes the Instrument Support Terminal. Using the IST, the Instrument Operations Team can schedule, monitor real-time telemetry, monitor replay telemetry (including spacecraft recorded telemetry), perform analysis, build command procedures, submit command requests, monitor commanding, review ground scripts, submit table loads and microprocessor memory loads, browse and submit updates to the instrument databases, receive event messages, access documentation, send and receive electronic mail to and from other ISTs and the EOC, build customized telemetry displays, and receive context-sensitive help.

The IST is a window into the EOC, providing much of the functionality available to the Flight Operations Team, only distributed to the PI/TL facility. The IST can be thought of as just another user station in the EOC with the following limitations:

- No real-time command capability
- Command requests may only be made for the particular PI/TL instrument
- Planning and Scheduling update requests may only be made for the particular PI/TL instrument

3.2.2.1 Conceptual IST Architecture

The IST provides remote access to EOC functions for the purpose of specific instrument scheduling, command requests, monitoring, and analysis. Its design

- Allows for multiple user access per instrument site
- Does not limit any IST capabilities to one physical IST
- Can be implemented on a variety of platforms
- Protects the EOC from unauthorized access

Since the IST is a collection of software that runs on PI/TL provided hardware, there are no restrictions on the number of software packages for any one instrument team. To manage EOC resources, there is a restriction on the number of ISTs that simultaneously can be logged in to the EOC. The number of simultaneous IST users is 15.

There are 12 dedicated simultaneous IST connections at the following locations:

- CERES 4 at Langley
- MODIS 2 at GSFC
- MOPITT 1 at U of Toronto, 1 at NCAR in Boulder
- MISR 2 at JPL
- ASTER 1 at the ASTER GDS
- Flight Dynamics Support 1 at FDD in EOC

In addition, 7 nondedicated IST connections are at the following locations:

- CERES 4 at Langley
- MODIS 1 at GSFC
- MISR 1 at JPL
- Valley Forge (AM-1 spacecraft developer)

3.2.2.2 IST Functional Requirements

The IST subset of EOC functions includes the following:

Planning and Scheduling: During all phases of scheduling, P&S provides authorized users with a set of tools for schedule development and global schedule visualization. The P&S Timeline tool provides the IOT at an IST with global visibility into planned operations of all EOS instruments and the spacecraft. The IOT may define activities for their instrument and submit scheduling requests using these activities.

Command Management: EOC tools that may be used to generate and maintain loads are available at the IST. These tools may be used to create or edit real-time-server (RTS) load contents files; to create or edit table load contents files; to transfer load contents files from an SCF directory to an EOC directory; to generate RTS, table, or microprocessor loads in uplink format and enter them in the EOC Load Catalog; to request the scheduling of the uplink of an RTS, table, or microprocessor load, and to view the list of loads currently available in the EOC Load Catalog.

Instrument Monitor: The IST allows a user to monitor spacecraft and instrument housekeeping and instrument engineering telemetry that is being received and processed in real-time at the EOC. Additionally, the IST allows a user to monitor simulations and historical telemetry replays that are currently being processed at the EOC. (Historical telemetry includes both real-time and spacecraft recorder telemetry.) The IST allows a user to display telemetry data from one or more instruments and/or one or more spacecraft simultaneously.

Instrument Analysis: The IST provides the user the capability to perform analysis of historical telemetry that is archived at the EOC or the DAAC. (Historical telemetry includes both real-time and spacecraft recorder telemetry.) Access to historical data is through the analysis tools that allow the static viewing of history data or through the replay of history data.

3.3 Spacecraft Data Capture and Distribution

EDOS is responsible for data capture from the spacecraft, interface of uplink commands, processing and distribution of Level 0 data, and Level 0 data archival. It provides space and ground interfaces between the EOS spacecraft via the SN/TDRSS and the EGS, the EOC, and DAAC elements of EOSDIS.

EDOS services include the following capabilities: EOS spacecraft data capture, playback processing, removal of science data overlaps and duplication, data quality checking and correction, annotation of missing or fill data, disassembly of the multiplexed EOS science data packets, and generation and distribution of PDSs and Expedited Data Sets (EDSs) to DAACs. EDOS provides level zero processed data sets within 21 hours of data reception.

EDOS is distributed over four types of facilities: GSIFs that interface with TDRSS and the two polar EOSDIS ground stations to store and forward return link data, a DAF for archival of Level

0 data, a Level 0 processing facility to produce Level 0 data and process real-time data, and a sustaining engineering facility (SEF) to support current and future EDOS operations. Figure 3-8 illustrates the EDOS configuration.

EDOS is not the exclusive provider of spacecraft data capture and distribution in the EGS, since some non-NASA EOS missions have made comparable but separate accommodations. Notable among these missions are ADEOS II, Jason, and Landsat-7. Level zero processing (LZP) capabilities for these missions exist at the National Space Development Agency (Japan) (NASDA), the JPL SeaWinds Project, Centre National d'Etudes Spatiales (France) (CNES), and the Landsat facilities at the EROS Data Center (EDC). The functional nature of these capabilities is equivalent to those of EDOS.

3.3.1 Conceptual EDOS Architecture

EDOS provides the data capture and distribution link between EOS spacecraft and the rest of the EGS. This link is considered a major component of the EGS because of the unprecedented volume of data expected to be recorded and archived from the EOS instruments. Since the EGS is an evolutionary system, EDOS is designed to address the evolution in spacecraft design, instrument design, ground system hardware/software, and standards. The EDOS design incorporates advances in information technology as well as communication, networking, data processing, and archival technologies. The EDOS is also designed with sufficient flexibility to accommodate rapidly changing requirements and demands generated by users.

Some of the key concepts driving the EDOS architecture areas include the following:

- Maintain compatibility with NASA Institutional Systems
- Use data-driven systems
- Automate operations
- Provide 24-hour year-round operations
- Provide common computer human interface capabilities
- Provide a sustaining engineering environment
- Support concurrent development, testing, and operation for the life of EOS plus 3 years
- Respond to evolution of EOS requirements while supporting operations
- Simultaneously support multiple spacecraft, each in a different phase of the life cycle
- Ensure that there is no single point of failure for real-time mission data handling services

3.3.2 Ground Station Interface Facilities

The Ground Station Interface Facilities (GSIFs) consist of functions necessary to monitor and capture high rate mission data received from the TDRSS Ground Terminal(s)—which consist of the White Sands Ground Terminal and the Second TDRSS Ground Terminal—or from the

EOSDIS ground stations, and to transfer captured data to the Level Zero Processing Facility (LZPF) at a reduced rate. GSIF capabilities are provided by the following functions:

a. The Short Term Data Capture function provides high-rate return link interface capabilities between the GSIF and the ground terminals for temporary capture of return link data from the spacecraft for subsequent transfer to the LZPF at reduced data rates. GSIF is also responsible for temporary storage of spacecraft data for 24 hours.

b. The Operations Management function provides the capabilities for GSIF control and monitoring and management interfaces.

c. The Return Link Monitoring function provides high-rate return link interface capabilities between the GSIF and the ground terminals and generates real-time return link physical channel quality and accounting data and transfers these data to the LZPF.

d. The System Support function provides support capabilities for GSIF hardware maintenance and capabilities to test the GSIF functions and interfaces, simulate external interfaces, execute tests, record data, and support external element interface testing.

The GSIF for AM-1 is located at the White Sands Facility. To back up White Sands, AM-1 backup ground stations located at Spitzbergen, Norway, and Alaska capture downlink data and forward the data via tape to the LZPF. Follow-on EOS missions (e.g., PM-1 and CHEM) will be primarily supported from GSIFs located with their Ground Terminal facilities at Spitzbergen, Norway, and Alaska.

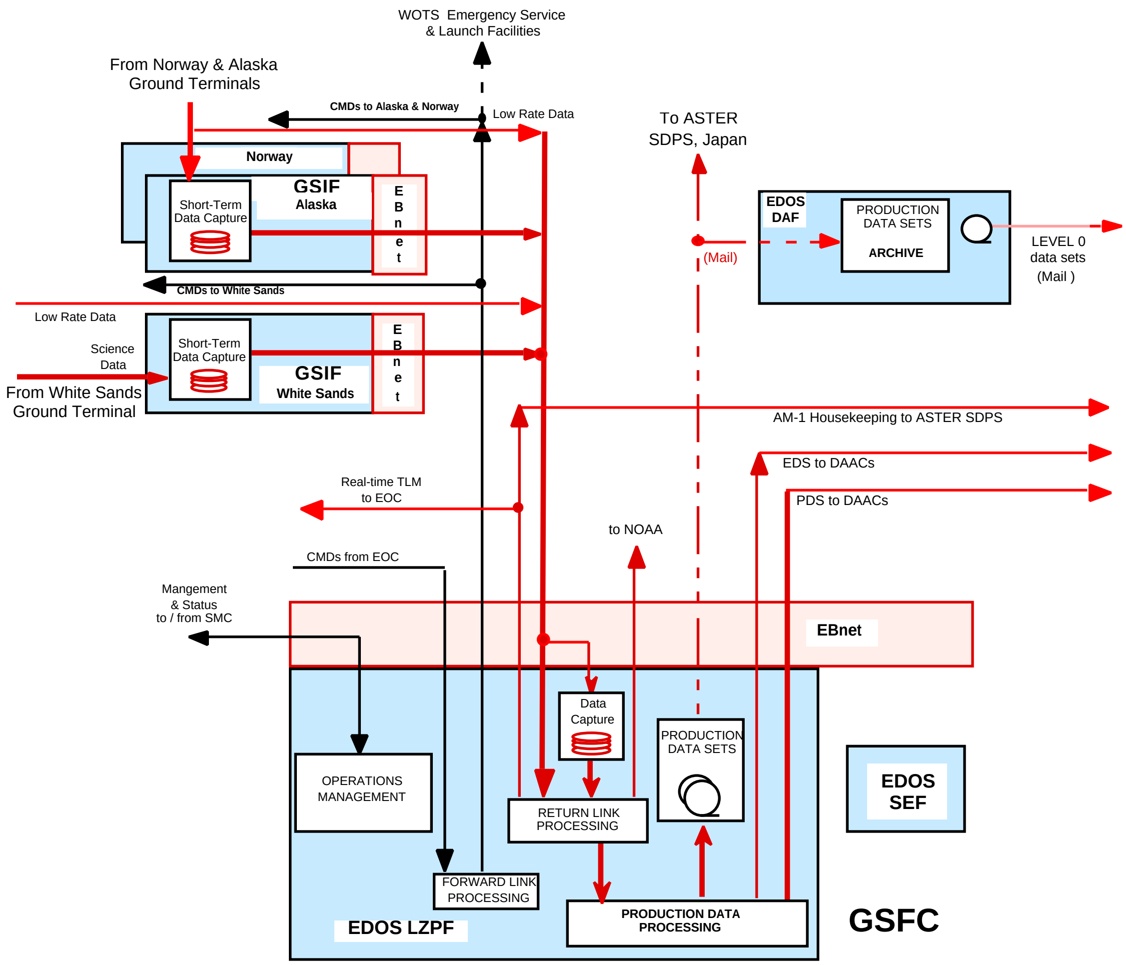

Figure 3-8. EDOS Configuration

3.3.3 Level Zero Processing Facility

The LZPF consists of functions necessary to process and transfer mission data between ground terminals and EGS elements. Processing performed by the LZPF consists of data capture, real-time forward link and return link processing, rate buffering, production data handling, and distribution of return link data. Production data handling consists of creation and distribution of PDSs and EDSs. In addition, the LZPF provides the EDOS system management and IV&V and maintenance support capabilities. LZPF capabilities are provided by the following functions:

a. The Data Capture function provides for capture and short-term storage of all received return link data.

b. The Return Link Processing function provides return link interface capabilities between the LZPF and the ground stations. It also provides the following:

- Generates return link physical channel quality and accounting data.
- Provides processing of return link data in support of the CCSDS virtual channel data unit (VCDU) and Path Services.
- Appends quality and accounting data to the return link data.
- Provides reversal of playback data, rate buffering, and transfer of return link data to its designated destination.

c. The Forward Link Processing function provides the forward link interface capabilities between the EOC and the ground terminals, generates quality and accounting data, and transfers forward link data to the EOS spacecraft via the TDRSS Ground Terminals, EOSDIS Ground Terminals, and WOTS.

d. The Production Data Handling function provides production data processing and expedited data processing. It also provides the following:

- Produces and distribute PDSs and EDSs with full quality and accounting data appended. Level zero data are distributed electronically or via removable physical media as PDSs within 21 hours of receipt. EDSs are distributed electronically.
- Produces PDS archive data for the EDOS Data Archive Facility (DAF) backup archive service.

e. The Operations Management function provides the capabilities of EDOS control and monitoring, planning and scheduling, and management interfaces. It also provides capabilities to coordinate the operations of EDOS services, monitor end-to-end performance, coordinate EDOS/EBnet fault management, verify operational readiness, and transfer EDOS service reports to EGS elements.

f. The System Support function provides support capabilities for EDOS hardware maintenance and capabilities to test the EDOS functions and interfaces, simulate external interfaces, generate test data, execute tests, record data, analyze test results, and support EGS element interface testing.

The LZPF is located at GSFC, Greenbelt, Maryland. It interfaces EDSs and PDSs electronically with the DAACs and provides PDSs on removable physical media via mail to the DAF and the ASTER SDPS in Japan. In addition, it interfaces real-time telemetry data between the EOC and the GSIFs and command data between the EOC and the ground stations.

3.3.4 Data Archive Facility

The DAF consists of functions necessary to accept and archive PDSs from the LZPF on removable physical media. The DAF distributes archived PDSs via removable physical media upon request. The DAF provides backup archive of all PDSs processed by EDOS for the life of EOS plus 3 years.

3.3.5 Sustaining Engineering Facility

The SEF is located at GSFC, Greenbelt, Maryland. The SEF provides EDOS with engineering support, operations management, system support, and communications interface.

a. Characteristics of engineering support services are as follows:

- Provides a hardware and software development/sustaining engineering environment
- Provides the capability to upgrade EDOS as system requirements change
- Maintains a library of historical data to track and manage EDOS project documentation, systems descriptions, user guides, utilities, test plans, and other related documents
- Provides for the development of training procedures, manuals, plans, and other functions required to train EDOS personnel

b. Characteristics of operations management services are as follows:

- Performs trend analysis on operational data from the GSIF and LZPF
- Monitors SEF systems
- Coordinates EDOS/EBnet operations and services, support fault isolation, and recovery processing
- Provides integration, test and verification support, and system maintenance support

3.4 Data Communications

Data communication for the EOSDIS is wide ranging and varied as befits a complex system of many modes, sites, and facilities. While the topography of the communication networks is concentrated in the lower 48 states of the continental United States, numerous international partners and users must also be served via data gateways and through existing external communication services.

The NASA Integrated Services Network (NISN) is NASA's new common use communications service network. The mission of the NISN is to provide cost-effective wide area network (WAN) telecommunications services for transmission of data, video, and voice for all NASA enterprises, programs, and centers, utilizing commercial capability wherever possible.

In general, the data communications for EOSDIS can be characterized as internal and external, where the internal capabilities are mostly provided by the EBnet or by other unique NISN capabilities, interconnecting dedicated capabilities within the EOSDIS, and the external capabilities are provided by the NASA Internet (NI) and the Internet, servicing remote investigators and user facilities. Table 3-2 shows the functions and providers for these two aspects of EOSDIS data communications. Data communications services are largely transparent and unobtrusive to the user.

Implementation of data communications for EOSDIS is primarily an extension or improvement of existing capabilities, using COTS products and commercially available components. Telecommunications circuits are acquired from common carriers using broad government contracts (e.g. FTS 2000). Bandwidth and circuits provide at least a 50 percent margin over the basic traffic estimates for the combination of each individual data flow or product specification in EOSDIS.

Table 3-2. Two EOSDIS Networks

NETWORK	**EOSDIS Backbone Network (EBnet)**	**NASA Internet (NI)**
FUNCTIONS	**Internal data flows:** • Real-time command and Control • Level 0 data • Production flow	**External data flows:** • ISTs • SCFs • QA • General users

3.4.1 EOSDIS Backbone Network

The EBnet Project provides a unique ground-to-ground data transport system for operational EOS communications; EBnet is being built to address EOS-specific requirements, although it may support other activities as well. The system provided by EBnet transports forward link commands, return link telemetry, payload science data, and operational data flowing among the DAACs, ground stations, EDOS, the EOC, the FDF, test and spacecraft support facilities, and selected project or instrument remote sites. Some of the requirements and goal for EBnet include the following:

- Implement an automated system maximizing use of COTS equipment
- Maintain compatibility with existing versions of NASA institutional systems, the Version 0 networks, and the IP Operational Network (IONET) systems as needed to meet EOSDIS requirements

- Transport traffic in a data-driven mode between specified locations as collected and maintained in an EBnet traffic database and provide a margin of capability beyond the specified aggregate flows
- Minimize life-cycle costs for implementation, operation, and maintenance of the network, operating with a minimum of human intervention
- Accommodate concurrent operations, simulators, and testing
- Allow for growth, adaptability to changing requirements, infusion of new technology, and upgrading of interfaces throughout its life cycle

The Network Management Control Center (NMCC) is a part of EBnet that monitors, manages, and controls the operation of the network and that interfaces with the ECS SMC.

The NMCC provides network monitoring and control capabilities to manage and display network topology and resource allocation; manages network operations, administration, planning and security functions; performs fault management functions, including fault detection, isolation, and resolution; and collects and reports accounting and network utilization information.

3.4.2 Other NISN Support

Certain circuit and related capabilities are provided to EOSDIS independent of the EBnet, from prior arrangements or because of the special nature or attributes of the service. This includes controlling and scheduling resources (the NCC), TRMM Project Science data acquisition by the SDPF, higher level data products flows by the TRMM Science Data and Information System (TSDIS), and Landsat-7 schedules and coordination information, calibration parameters, and spacecraft and instrument performance data..

3.4.3 NASA Internet

The NI is an open computer communications network that serves the needs of NASA's diverse science and research community worldwide. NI's mission is to support NASA's scientific goals and objectives by providing reliable global network communications for scientific research. It accomplishes its mission by identifying and managing all existing and future NASA science network requirements, engineering high-quality solutions in a evolving environment, developing tools to enhance the usefulness of the network, and providing information on how to find and use networking resources.

NI was established in 1988. In 1989, both the DECnet-based Space Physics Analysis Networks and the Transmission Control Protocol/Internet Protocol (TCP/IP) based NASA Science Network were brought together as a single project called NSI. Today, NI is a high-speed, multiprotocol, international network that supports both DECnet and TCP/IP protocols. NI currently serves nearly 10,000 NASA researchers and collaborators worldwide, with high-performance links and gateways connecting to several thousand research, educational, and public commercial networks via the Internet and national research networks in Europe, Asia, and other continents.

In EOSDIS, the NI will connect the DAACs, SCFs (ISTs), and the EOC within ECS for planning and scheduling; will support flight operations; and will perform monitoring and coordination activities. It will connect the ISTs, SCFs, and quality control (QC) SCFs within EOSDIS, as well as general users, ADCs, ODCs, and other external partners.

3.4.4 Other Data Communications Capabilities

The WANs provided by EBnet and NI typically connect to LANs at each site that are provided by the host there. In a few instances, EBnet provides the data flow at a local site in place of the LAN (e.g. at EDC for Landsat-7 data), but this circumstance is an exception.

Mail is also used as a data communications tool within the EOSDIS for archive products on hard media and for productions data sets in some cases.

3.5 System Monitoring and Coordination Center

Formerly called the System Management Center, the SMC is one of the elements of the ECS CSMS. This element performs systemwide, site, and element resource and operations monitoring and provides these services to the other ECS elements. The SMC interacts with all the other elements of the ECS as well as interfaces with external systems, ADCs, and ODCs.

The main mission of the SMC is to provide a center where a systemwide view of the ECS operations can be maintained for operations personnel. This center, located at GSFC, can provide systemwide coordination of activities at individual sites and element locations by providing high-level resource configuration directions and schedule adjustments. The center also provides a source for systemwide administrative, security, and accounting management. Operations personnel guide these services.

To accomplish effective coordination between the SMC and the other ECS elements, the SMC provides each element with LSM services. The LSM is the local management and operations component running on each element’s architecture. The LSM provides means by which local management and operations personnel control and monitor their ground resources.

Site managers monitor each of their element’s ground operations activities at their particular sites.

SMC monitors the ground operations events of each site and element.

Communication is established among the SMC, sites, and elements for management operations information, including directives, status, and user information.

Figure 3-9 shows the context of the SMC in EOSDIS. The interaction between the SMC and the ECS elements and the other interfaces varies from element to element and from place to place. Coordination of activities extends into CM, security, engineering maintenance, logistics, and upgrades for the managed ECS elements.

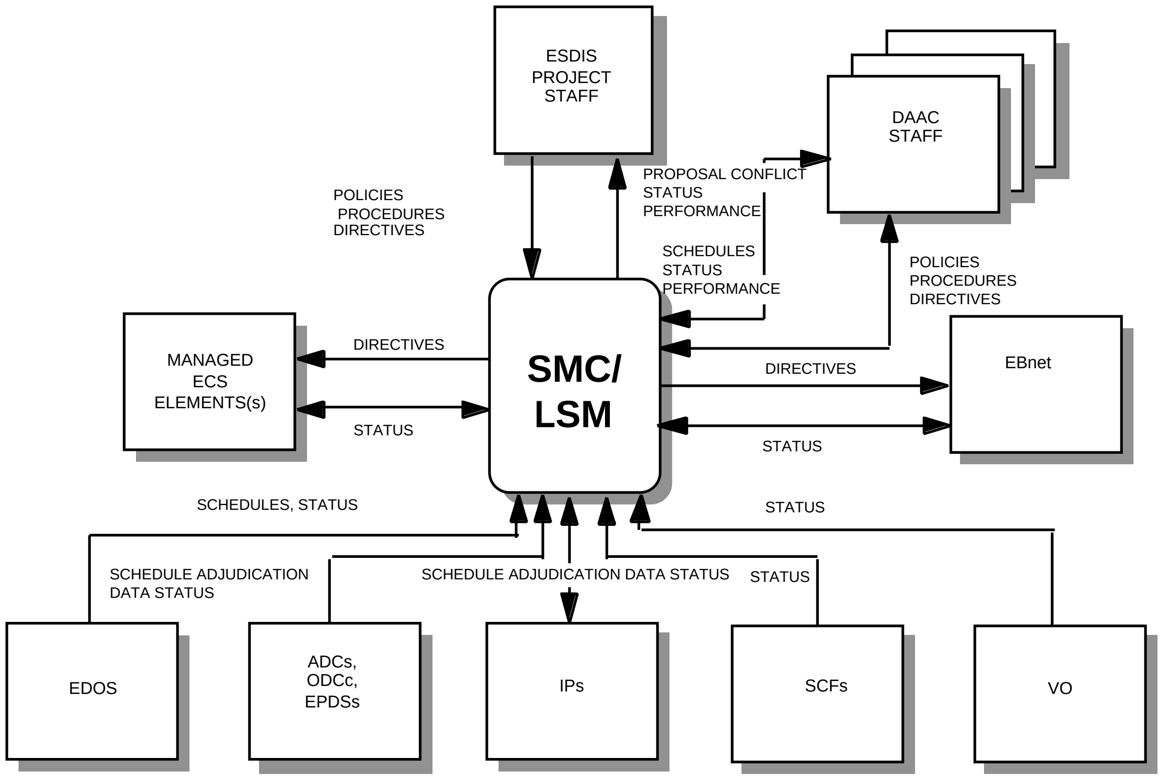

Figure 3-9. SMC in Context With EOSDIS

3.5.1 SMC Implementation

Implementation of the SMC is accomplished via a systems management subsystem (the MSS). Figure 3-10 shows the MSS high-level context. The MSS is composed of a combination of COTS and custom management applications to provide a highly automated means for monitoring and managing the various ECS resources. At each ECS installation, maintenance and operations (M&O) staff autonomously provide local management services associated with its ECS resources, and hence, they are provided a local management view. At the GSFC SMC, M&O staff provide enterprise monitoring and coordination services associated with all ECS installations, and they are provided a systemwide management view. The MSS applications provide extensive configurability to enable these views to be shared or controlled as necessary on the basis of ECS management policy. In addition to providing these views to M&O staff for monitoring and control purposes, the management services make use of legacy communications subsystem (CSS) services, such as electronic mail and bulletin boards for coordination. The services provided by CSMS at the SMC, located at GSFC, are collectively referred to as Enterprise Monitoring and Coordination (EMC). In the same context, services provided by CSMS at DAACs and the EOC (sites) are collectively referred to as LSMs.

The MSS provides EMC (network and system level) for all ECS resources: commercial hardware (including computers, peripherals, and network routing devices), commercial

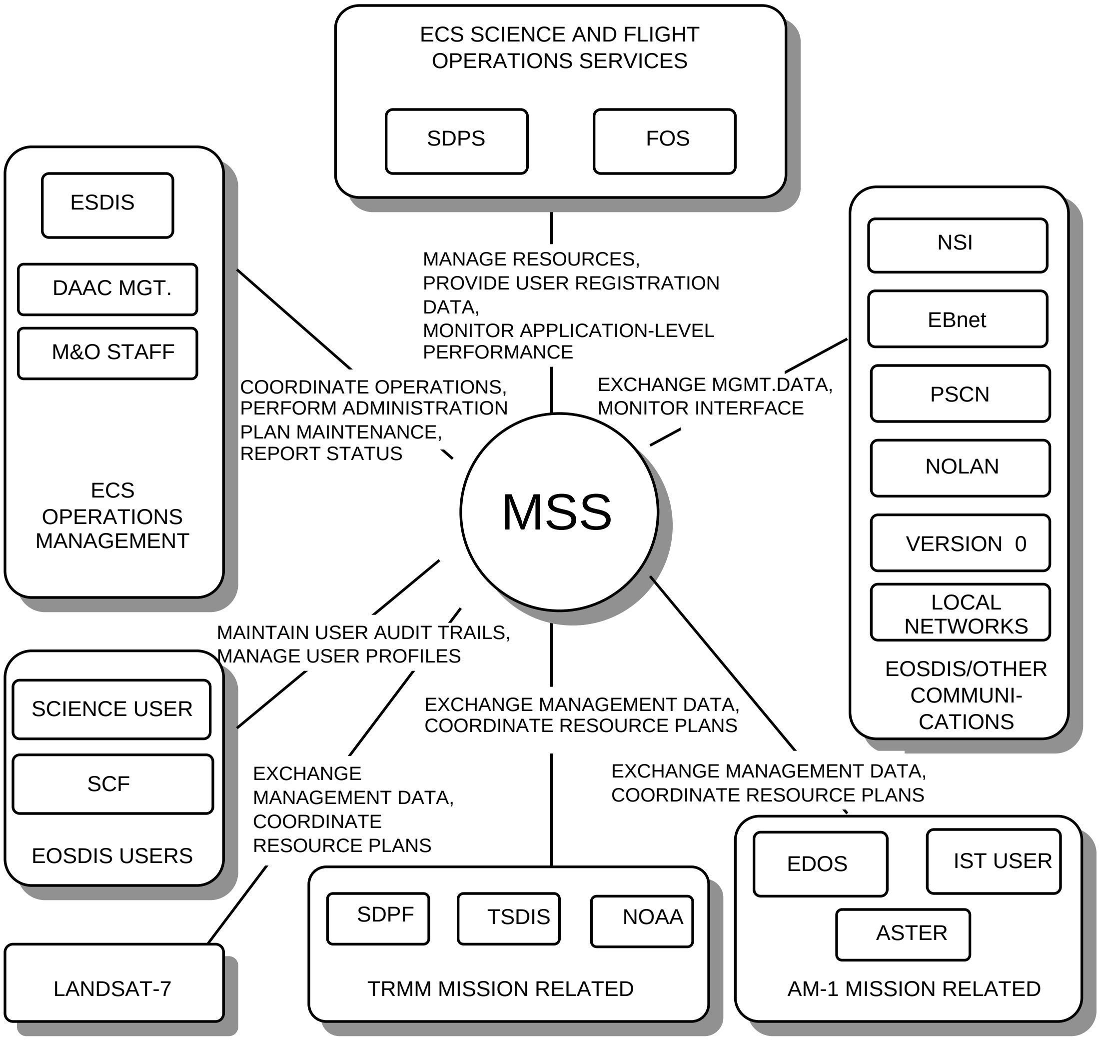

Figure 3-10. MSS High-Level Context

software, and custom applications. EMC reduces overall development and equipment costs, improves operational robustness, and promotes compatibility with evolving industry and government standards. Consistent with the current trends in industry, the MSS thus manages both ECS's network resources as per EBnet requirements and ECS's host/application resources as per SMC requirements. In addition, the MSS also supports many requirements allocated to SDPS and FOS for management data collection and analysis/distribution.

3.5.2 MSS Service Allocation

The MSS allocates services to both the systemwide and local levels. With few exceptions, the management services are fully autonomous, and no single point of failure exists that would preclude user access. In principle, every service is distributed unless an overriding reason demands it to be centralized. MSS has two key specializations: EMC and LSM. The distribution of these services, shown in Table 3-3, provides maximum flexibility and policy neutrality in the design and implementation of MSS services.

Client-server system management application services for distributed enterprises, such as ECS, are not commercially available today. A framework has been chosen for integration of multivendor network and system management products to support migration to a fully integrated management solution as such products become commercially available.

The MSS is largely in the application domain, above the Open Systems Interconnection Reference Model application layer services. The management applications are supported by, and are functionally dependent on, other MSS and CSS services. The Management Agent Services are used to monitor and control managed objects (such as network, hardware, and software) within each management domain and provide the primary means of communicating status and control information between managed objects and management applications.

3.5.3 MSS Implementation

The MSS is implemented mainly through the use of COTS, with some “wrapper” and custom code to support ECS-unique requirements and a layer of abstraction from COTS to minimize effect of migration of new technology or enhancements. The selection of each COTS package takes into consideration factors such as ECS requirements, commonality of the man-machine interface, integration with the chosen framework, adherence to standards, vendor track record, and flexibility of operation.

The MSS implementation uses the common framework for integration of the suite of common management functions, providing elements of fault management, CM, accountability management, performance management, security management, and mode management. This framework and integrated applications use the de facto industry standard Simple Network Management Protocol (SNMP) as the primary means of monitoring and controlling ECS management objects.

Table 3-3. Management Service Distribution (1 of 3)

Management Service	EMC	LSM	Comments
Policies and Procedures	Provide policy decisions, coordinate policy, monitor policy compliance	Coordinate policy and site-level policy decisions, policy compliance monitoring and reporting	Policy management and decisions are made by people using these tools
Fault Management	Receive summary reports from sites; monitor systemwide resources (WANs); perform trend analysis	Monitor, detect, isolate, diagnose, and recover from faults within domain	Largely COTS capabilities (HPOV); EMC maintains systemwide view from site updates and monitoring
Performance	Provide trend analysis and systemwide view from site updates	Collect server, hardware, and network performance data, analyze performance data; tune and report to SDPS/ FOS/EMC	Site performance is cooperative effort between LSM and SDPS/ FOS; trends are through rollup of site reports
Trouble Ticketing (TT)	Provide summary reports; view selected site problems, support resolution	Document problem reports, track actions and closure; provide user and resource summaries	Remedy selected as TT package
Physical Configuration Management	Maintain same information as LSMs	Maintain physical location and configuration information	Commercial package to locate and record resources; detects changes to approved configuration
Security	Provide policy flowdown, systemwide monitoring and analysis	Provide DCE cell management	Authentication, authorization, intrusion detection, distributed computing environment cell management; largely public domain and COTS, HAL for cell management policy flowdown; administration is through offline analysis tools
Inventory	Create and manage systemwide inventory	Maintain and manage site inventory data	Automated

Table 3-3. Management Service Distribution (2 of 3)

Management Service	EMC	LSM	Comments
Logistics	Provide systemwide monitoring of spares and consumables	Provide site-level monitoring of spares and consumables including replenishment	Automated
Maintenance	Provide systemwide maintenance analysis	Establish and maintain PM schedules; monitor and coordinate offsite maintenance	Automated
Configuration Management	(Software Change manager)	Provide software CM of ECS baseline	
Baseline Manager	Provide consolidated baseline for systemwide configuration and dependencies	Maintain site baseline for operational system configuration	
Change Request Manager	Maintain system-wide status of change requests	Maintain record of configuration change requests; track status	
Training	Coordinate training schedules, curricula, user feedback, and develop materials	Provide input on training schedules, curricula, local course development, and evaluation	Automated
Planning	Provide systemwide schedule policy, priorities, performance assessment, systemwide ground event coordination	Schedule own resources based on systemwide priorities and policies; plan ground events; and interface with FOS and PDPS	
Reports	Provide systemwide reporting based on “rollup” of site-level data	Provide site-level reporting on performance, security, fault, and configuration information	

Table 3-3. Management Service Distribution (3 of 3)

Management Service	EMC	LSM	Comments
Billing and Accounting	Receive user resource utilization and data order information; provide capability to price resources and products; maintain standard pricing tables; generate statements of account and bill invoices; track accounting data	Collect and provide user resource utilization and data order information; query account data	Tracking and billing for resources used by users
Mode Management	Coordinate and monitor mode activities across sites	Coordinate and monitor mode activities within a given site	Maintain systemwide view and control of different modes of activity

The MSS design depends heavily on COTS products, each of which is configured to support ECS-unique requirements. Custom code development for services is roughly uniform across each service and is estimated at 50 to 60 KSLOC. The framework must be configured to support the ECS-specific design and implementation. Part of this configuration can automatically detect network devices that support the industry standard SNMP. Identification of other ECS-managed objects is provided by custom development in the Management Agent to add these elements to the database. This information, along with mode management information, is used to build operations maps that depict the logical layout of network devices and other ECS-managed objects. Part of the configuration then entails the definition of operation "views" that support different operation modes within ECS. A second significant part of the configuration is developing scripts that define action routines for each event that is received for each managed object. The other services shown in Table 3-3 require varying amounts of configuration and customization. Integration effort into the framework is minimized through selection of COTS that have already been integrated by the vendor whenever possible.

The hardware for MSS contains an Enterprise Monitoring server, LSM servers, management workstations, and printers. The selection of these configurations results from requirements and trades analysis and performance, RMA, security, and evolvability considerations. Hardware configurations and sizing are made DAAC specific. Major design drivers include the number of managed objects, size and frequency of data to be collected about the managed objects, data distribution, data retention and archiving design, and COTS choices.

3.6 EOS Test System

The EOS Test System (ETS) consists of three data flow simulators located at GSFC Building 32 that test key EOSDIS data interfaces at the EOC, DAACs, EDOS, and Ground Terminals. These three simulators are as follows:

- The Multimode Portable Simulator (MPS)—low fidelity spacecraft simulator to support testing of forward-link and non-science return-link processing
- The High-Rate System (HRS)—EOSDIS return-link science data processing and interface test tool
- The Low-Rate System (LRS)—functional EDOS interface between the EOC and either the Spacecraft Integration and Test Facility (SCITF) or Spacecraft Simulator (SSIM).

NASA GSFC Code 515 is developing the ETS.

3.6.1 Conceptual ETS Architecture

The ETS components are shown in context with the EGS in Figure 3-11. The architecture of the ETS is driven by the large difference in data rates to be simulated, the need to support five configurations for testing and simulations, and the utilization of in-house technology. Figure 3-12 illustrates the ETS architecture.

3.6.2 ETS Functional Requirements

3.6.2.1 MPS Functions

The MPS simulates the S-band telemetry and command format interfaces with the EDOS and EOC, as well as the spacecraft command and telemetry interface. Its functions include the following:

- Simulate S-band telemetry formats (512 kbps playback, 16 kbps real time) and receive spacecraft commands (2 kbps or 10 kbps) to test the interface with EDOS
- Simulate low-rate telemetry formats and receive spacecraft commands in Nascom blocks to test contingency network interfaces to EDOS through EBnet
- Simulate and transmit low-rate telemetry in EDOS formats to the EOC and receive spacecraft commands from the EOC or EDOS as command data blocks
- Use the AM-1 PDB files for telemetry generation and command verification
- Provide limited telemetry responses to valid spacecraft commands
- Provide Operations Management Data simulation capabilities for subset of EDOS and EOC OMD

3.6.2.2 HRS Functions

The HRS simulates the high-rate science data stream to test the interfaces of the DAACs, EDOS, and ground terminals. Its functions include the following:

- Simulate ground terminal high-rate return link by transmitting up to two 150-Mbps serial data streams.
- Simulate EDOS output by transferring data sets to a DAAC via EBnet at sustained data rates up to 34 Mbps.
- Simulate the DAAC front end by capturing EDOS data sets via EBnet at sustained data rates up to 34 Mbps.
- Accept and playback SCITF test data on Ampex tapes.

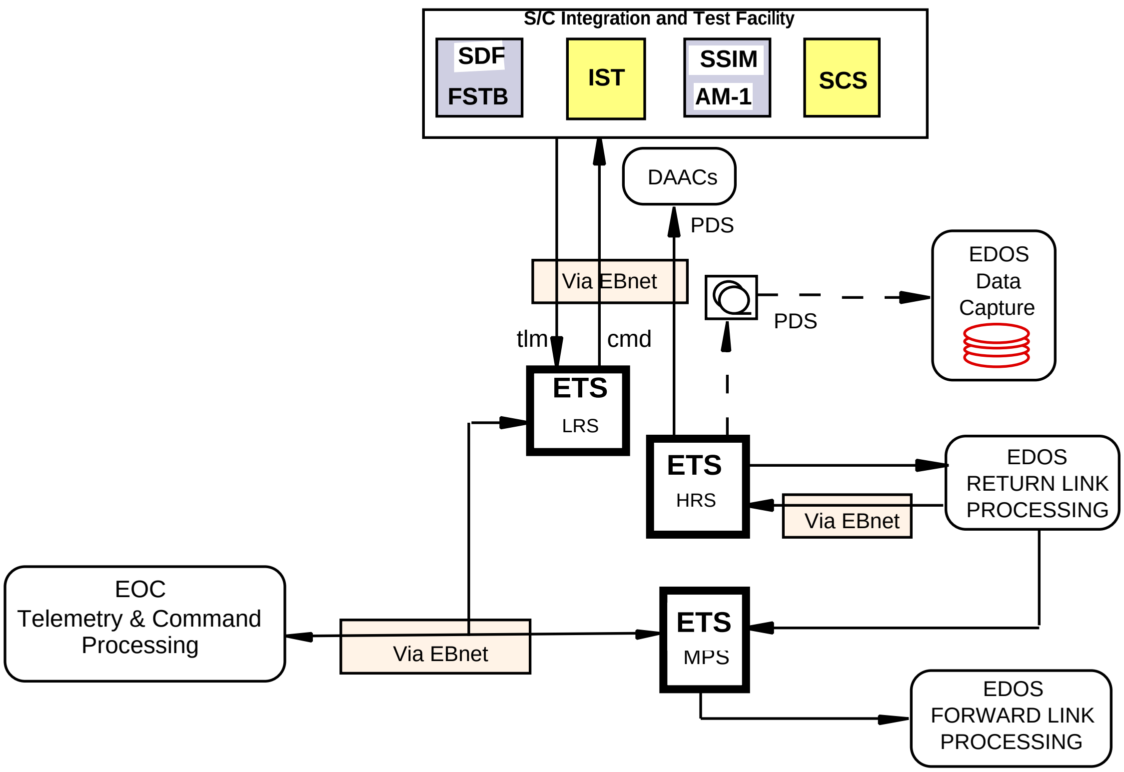

Figure 3-11. ETS Context With EGS

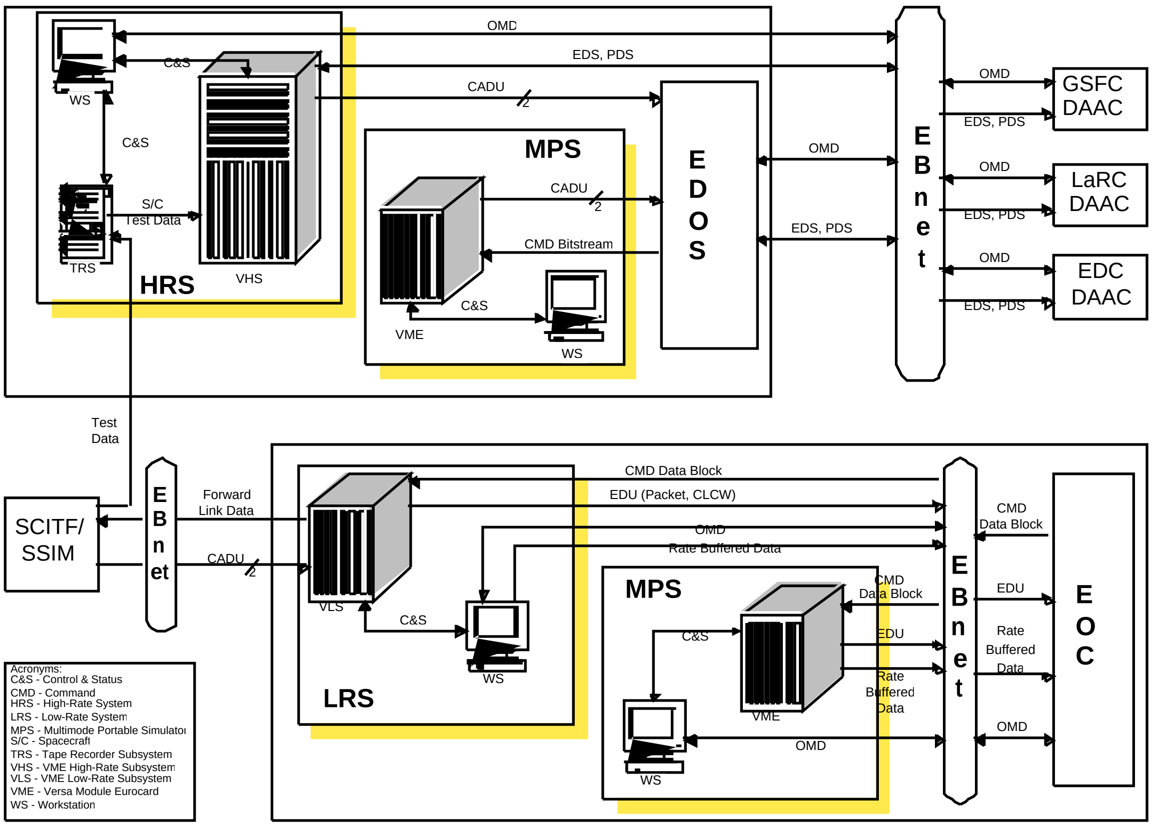

Figure 3-12. ETS Architecture

- Process SCITF test data to generate channel access data unit (CADU) files, and EDOS-compatible EDS and PDS.
- Provide a graphical unit interface based control environment that supports automated operations.

3.6.2.3 LRS Functions

The LRS simulates the EDOS forward link and return link processing functions. Its functions include the following:

- Simulate EDOS forward link processing functions by receiving Command Data Blocks, checking EDOS ground message headers, extracting forward link data, and forwarding it to SCITF/SSIM
- Transmit forward link data to SCITF/SSIM at 125 bps, 1 Kbps, 2 Kbps, or 10 Kbps
- Simulate EDOS low rate return link processing functions by receiving and processing up to two S-band serial data streams

- Perform return-link processing at data rates up to 1 Mbps
    1) Process up to 8 spacecraft IDs (SCID)
    2) Process up to 31 Virtual Channels
    3) Process up to 521 application process identifiers
    4) Process up to 521 sources
- Transmit return link data as electronic data units (EDUs) and rate buffered data files
- Provide a graphical unit interface based control environment that supports automated operations

3.6.3 ETS Interfaces

Figure 3-13 summarizes the major ETS interfaces.

3.7 EOSDIS Ground Stations

High latitude ground stations located in Alaska and Spitzbergen, Norway, will be implemented for support of EOS missions, beginning in 2000 with the PM-1 mission. These stations will interface low- and high-rate data with the EDOS in the same manner as White Sands. (Also see section 3.8.3.)

3.8 NASA Institutional Support Systems

The major NISS components supporting the EGS are the TDRSS Ground Segment, the NCC, WGS, and the FDD/FDF. Figure 3-14 shows the NISS interfaces.

3.8.1 TDRSS Ground Segment

The TDRSS Ground Segment is used for primary tracking, telemetry, and command operations for the AM-1 spacecraft. The TDRSS ground segment consists of the White Sands Ground Terminal and the Second TDRSS Ground Terminal, located at the White Sands Complex (WSC) in Las Cruces, New Mexico. The TDRSS Space Segment consists of a constellation of TDRSs in geosynchronous orbit that provide S-Band Single Access (SSA), S-Band Multiple Access (SMA), and Ku-Band Single Access (KSA) tracking and data communications services to low Earth orbiting satellites. TDRSS support is scheduled and controlled by the NCC.

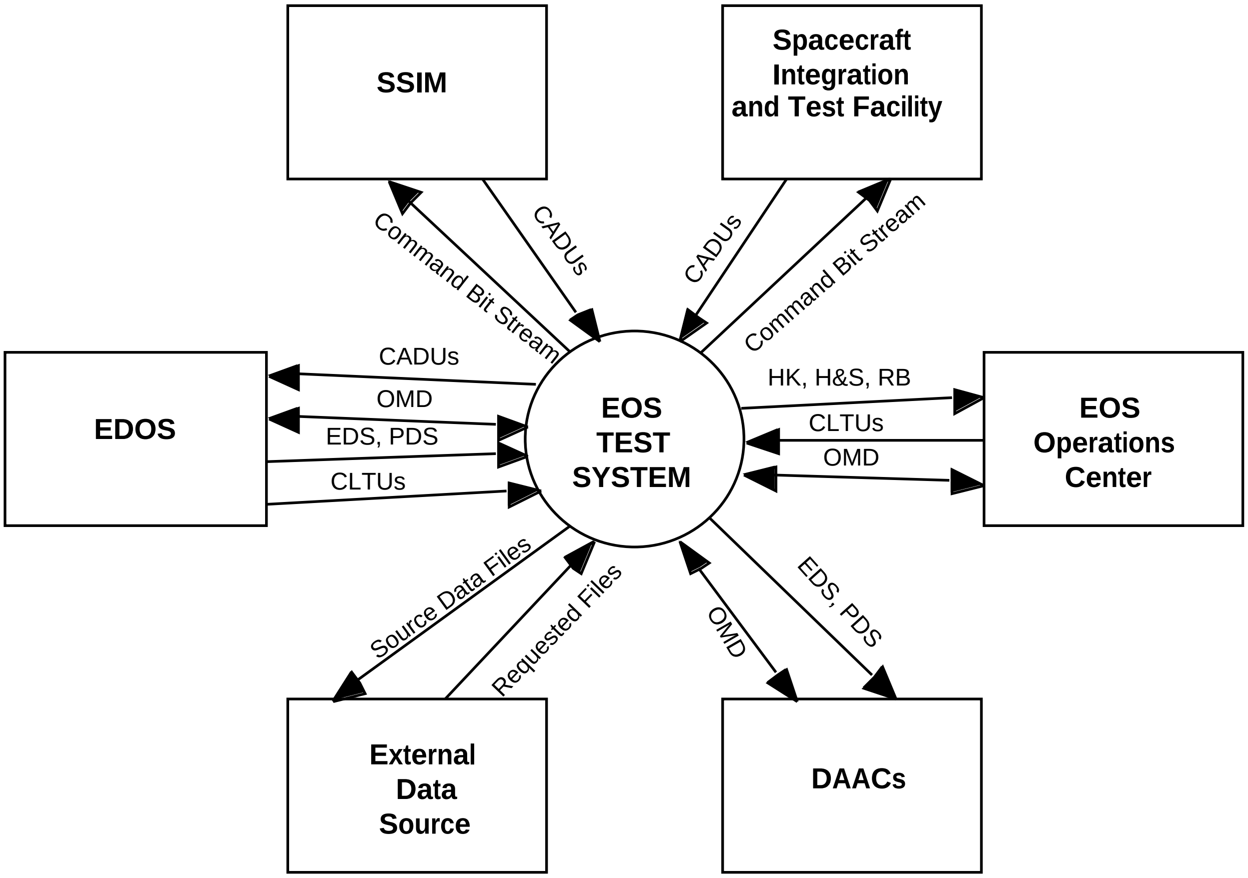

Figure 3-13. Major ETS Interfaces

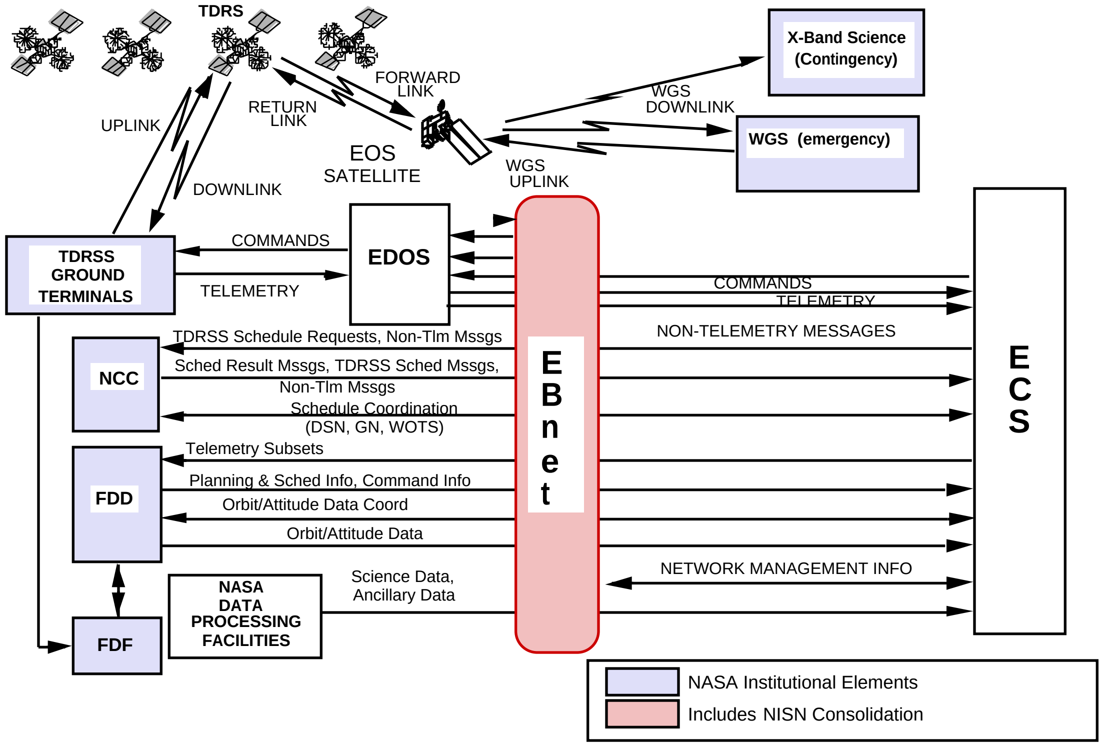

Figure 3-14. NISS Interfaces

3.8.2 Network Control Center

The NCC is the focal point for management of the SN and the GN. The NCC is responsible for scheduling of TDRSS operations and the performance of link monitoring and fault isolation. The NCC Data System consists of three major segments: The Communications and Control Segment, the Service Planning Segment, and the Intelligent Terminal Segment. In addition, a Service Accounting Segment is an offline element that provides accounting for the use of the services and resources of the SN as planned by the Service Planning Segment.

3.8.3 Wallops Ground System (WGS)

These facilities are utilized for emergency backup support.

3.8.3.1 Wallops Ground System

The WGS, located at Wallops Island, Virginia, provides tracking, telemetry, and command support for the non-TDRSS compatible low Earth orbiting satellites and S-band emergency support for the TDRSS satellites.

The WGS also serves the EOS program in a backup contingency mode for relaying housekeeping telemetry and low-bit rate commands between the EOS spacecraft and the EDOS

LZPF. In addition, X-band WGS will be located in Alaska and Spitzbergen, Norway, to provide backup TDRSS science data downlink service to EOS AM-1.

3.8.3.2 Wallops Orbital Tracking Information System

The Wallops Orbital Tracking Information System (WOTIS) is the scheduling and coordination activity for the WGS, AM-1 backup stations, and for the EOSDIS Ground Stations.

3.8.4 NASA Integrated Services Network

The NISN will be used to transport science and ancillary data from NASA data processing facilities (such as the GSFC SDPF) to the DAACs for designated NASA missions like TRMM.

3.8.5 Flight Dynamics Support

The FDD will provide orbit and attitude support for the EOS AM-1 spacecraft by monitoring spacecraft attitude and navigation system performance and providing orbit and attitude products to support the EOS flight operations and science processing. Most of this support will be provided via the FDD capabilities resident within the EOC, but other support (e.g., L&EO, TDRSS orbit, standard files) will be provided by the FDF. The FDD will provide orbit and attitude determination for selected future EOS spacecraft as needed and required. Major functions of Flight Dynamics support include the following:

- Provide orbit predictions, planning data, and uplink products
- Provide attitude determination support, both realtime and definitive
- Provide orbit maneuver support
- Receive all tracking data transmitted to GSFC for real-time validation (FDF)
- Capture all backup tracking data (FDF)
- Maintain a database of tracking data to be used for orbit computations (FDF)
- Provide “repaired” orbit data products
- Provide mission analysis support
- Provide guidance, navigation, and control system verification
- Perform prelaunch services (e.g., trajectory analysis, sensor analysis, and operations planning)

3.9 Spacecraft Ground Support Components

3.9.1 Spacecraft Simulator

The SSIM provides ground-based simulation capabilities of the EOS AM-1 spacecraft Command and Data Handling (C&DH) subsystem. The simulation capabilities support EOS ground system test and training activities. They include support for training control center operators and testing operational procedures. The AM-1 SSIM, developed by the AM-1 spacecraft vendor, is located at GSFC. EOS missions subsequent to AM-1 will use mission simulators provided by the spacecraft contractor.

3.9.1.1 SSIM Description

The SSIM provides real-time simulation of the EOS spacecraft to support testing of flight software loads and databases, testing of operational procedures, spacecraft flight operator training, anomaly investigation training, and ground test support. The SSIM includes the following capabilities:

- Simulate and conduct spacecraft operation integration and tests, such as Spacecraft Control Computer flight software memory loads/updates and operation readiness, in support of the EOS spacecraft IV&V functions.
- Simulate end-to-end tests with ground system interfaces.
- Host spacecraft mission and simulation software.
- Simulate real-time spacecraft during various mission profiles.
- Utilize an interactive user interface, with scripted procedures.
- Function in standalone or training mode of operation.
- Provide real-time EOC interface (command and telemetry).
- Provide an administrative interface (file transfer) with FDD, contractor plant, or EOC.
- Simulate high-fidelity spacecraft dynamics, navigation, and attitude control (normal and safehold).
- Simulate low-fidelity power and thermal telemetry.
- Simulate appendage deployment.
- Simulate C&DH components (standby command and telemetry interface unit [CTIU]), solid state recorder).
- Provide canned response to commands for instruments.
- Initiate all software FDIR services.

3.9.1.2 SSIM Design Drivers

- The SSIM has the capability to receive AM-1 spacecraft and instrument commands in CCSDS command link transmission unit (CLTU) format.
- The SSIM has the capability to send (in EDUs containing CCSDS telemetry packets) simulated real time AM-1 spacecraft and instrument housekeeping telemetry packets and command link control words.
- The SSIM has the capability to send (in EDUs containing CCSDS telemetry packets) simulated recorded AM-1 spacecraft and instrument housekeeping telemetry packets.
- The SSIM has the capability to send (in EDUs containing CCSDS telemetry packets) simulated AM-1 SCC, CTIU, and instrument microprocessor memory dump telemetry.

3.9.2 Software Development and Validation Facility

The EOS ground support includes one SDVF. The SDVF is located at the AM-1 vendor facility in Valley Forge, Pennsylvania, and contains flight software development tools and flight software diagnostic tools.

3.9.2.1 SDVF Description

The SDVF generates and tests flight software updates and provides flight software loads to the EOC for uplink to the EOS spacecraft.

3.9.2.2 SDVF Design Drivers

SDVF design drivers include

- Maintenance of flight software validation database
- AM-1 flight loads and updates from SDVF to EOC
- AM-1 flight software dumps from EOC to SDVF

3.9.3 Spacecraft Analysis Software

Spacecraft Analysis Software (SAS) is developed by the AM-1 spacecraft contractor to provide flight performance analysis and evaluation for the AM-1 spacecraft. These functions include analyzing spacecraft performance trends, detecting failures, and evaluating subsystem performance. The SAS is hosted on a workstation in the EOC.

The SAS functions include analyzing spacecraft performance trends, detecting incipient failures, and evaluating subsystem performance.

The analysis software provides anomaly resolution support to the EOS FOT by performing calibrations, analyzing failures, evaluating solutions, validating procedures, reconstructing and simulating failure scenarios, and supporting anomaly diagnosis and resolution.

3.9.4 Spacecraft Checkout Station

The AM-1 Spacecraft Checkout Station (SCS), developed by the AM-1 spacecraft vendor, supports AM-1 prelaunch integration and testing at the AM-1 spacecraft vendor facility in Valley Forge, PA, and at the launch site, Vandenberg Air Force Base. The SCS can be configured to support several testing configurations, from spacecraft simulation to full-up spacecraft launch site testing. The SCS can be configured to generate and provide AM-1 telecommand CLTUs to the spacecraft and receive encoded CADUs from the spacecraft. In this configuration, the testing is conducted without EOSDIS ground system (EDOS, EBnet) involvement. Optionally, the SCS also can be configured to receive CLTUs from the EOC through the EBnet/EDOS/ETS interface and forward these CLTUs to the spacecraft. The SCS also can forward AM-1 telemetry CADUs to the EOC through an EBnet/EDOS interface.

Appendix A. EGS Support of EOS-Related Missions

This appendix describes the various missions related to the EOS program but not specifically dedicated to EOS. These EOS-related missions include spacecraft from non-EOS programs flying some instruments that are dedicated to the EOS program. Figure 1-2 shows the EOS related systems and interfaces supporting the TRMM, Landsat-7, ADEOS-II, and EO-1 missions.

A1 Tropical Rainfall Measuring Mission

TRMM is a joint NASA/NASDA mission designed to advance understanding of total rainfall and the rate of rainfall in the tropics. The TRMM satellite carries both NASA and Japanese instruments. EOSDIS ingests and archives TRMM data products and instrument data. Figure A-1 provides an overview of the TRMM data flow and interfaces.

The TRMM ground support components provides data collection and analysis services for the TRMM project. The following instruments are planned to fly on the TRMM Spacecraft:

- CERES Cloud and Earth Radiant Energy System
- LISLightning Imaging Sensor
- PR Precipitation Radar
- TMI TRMM Microwave Imager
- VIRS Visible Infrared Scanner

The Sensor Data Processing Facility (SDPF) and the TRMM Science Data and Information System (TSDIS) provides data collection, analysis, and product generation services for PR, TMI, and VIRS instruments. These data and data products are then sent to the TRMM Support System (TSS) at the GSFC for archival and distribution.

Additionally, the SDPF also provides data collection services for two EOS instruments (CERES and LIS) flying on the TRMM spacecraft. These data are then provided to the Langley TRMM Information System (LATIS) and the LIS SCF, respectively, for data analysis, product generation, archival, and distribution services. The TRMM ground support components are responsible for distributing these data and products to the respective science teams and users.

The TRMM ground support services are provided by five elements, the SDPF, TSDIS, LATIS, TSS, and LIS SCF. The ground facility for capturing TRMM data is the SDPF, which is a multiproject facility located at GSFC. The SDPF is a Level 0 ground system designed to capture and process packet telemetry data that adhere to packet forms prescribed by the CCSDS recommendations. The TRMM science data undergoes Level 0 processing at the SDPF, and it is then forwarded for Level 1 through Level 4 processing to the appropriate data analysis and archive facilities.

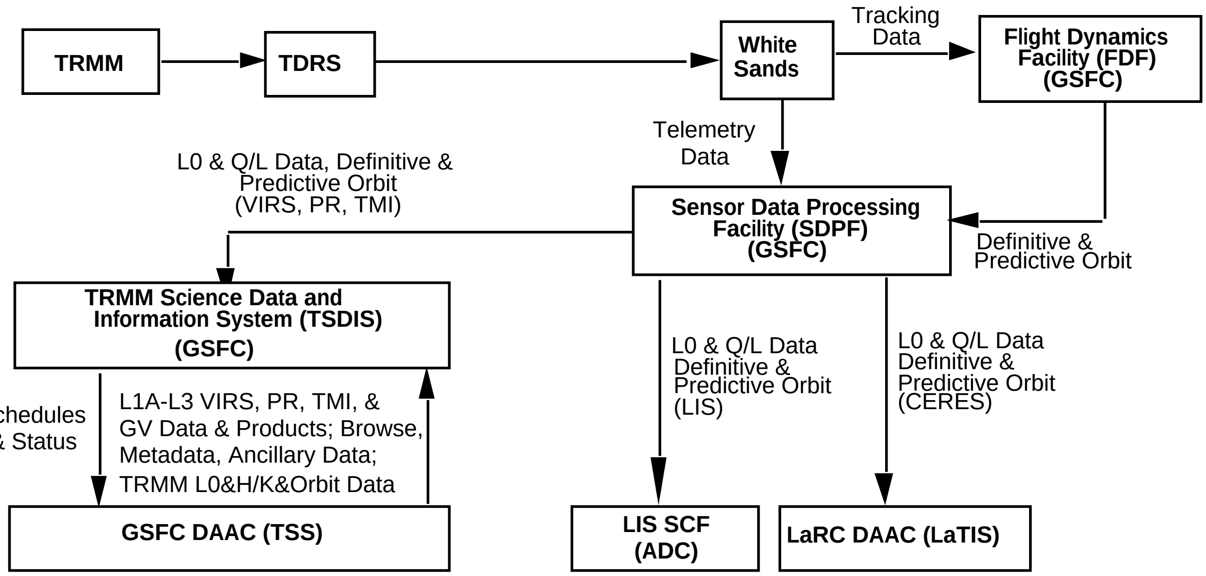

Figure A-1. TRMM Data Flow

The TSDIS is responsible for science planning and instrument monitoring coordination. It is also responsible for higher level processing of production data products for PR, TMI, and VIRS. Ancillary ground truth data and data from supporting field experiments required for data processing and validation are stored at TSDIS. Data products generated by TSDIS are available to the TRMM science team via the TRMM Science Network.

A2 Landsat-7

The Landsat-7 ground support components provide distribution and user interface services. Figure A-2 shows the ground support components and Landsat-7 data flow.

The major functions of the Landsat-7 Ground Station (LGS), located at the EDC in Sioux Falls, SD, are the capture and recording of the wideband data via direct X-band downlinks. These data are also collected at the high latitude AM-1 backup stations. The data are routed to the LPS.

Upon receiving the wideband data from the LGS, the LPS processes the data to create Level 0R files. These processed files are stored temporarily at the LPS and sent to the EDC DAAC for archive and further processing. Included in this file set are engineering data, browse data to

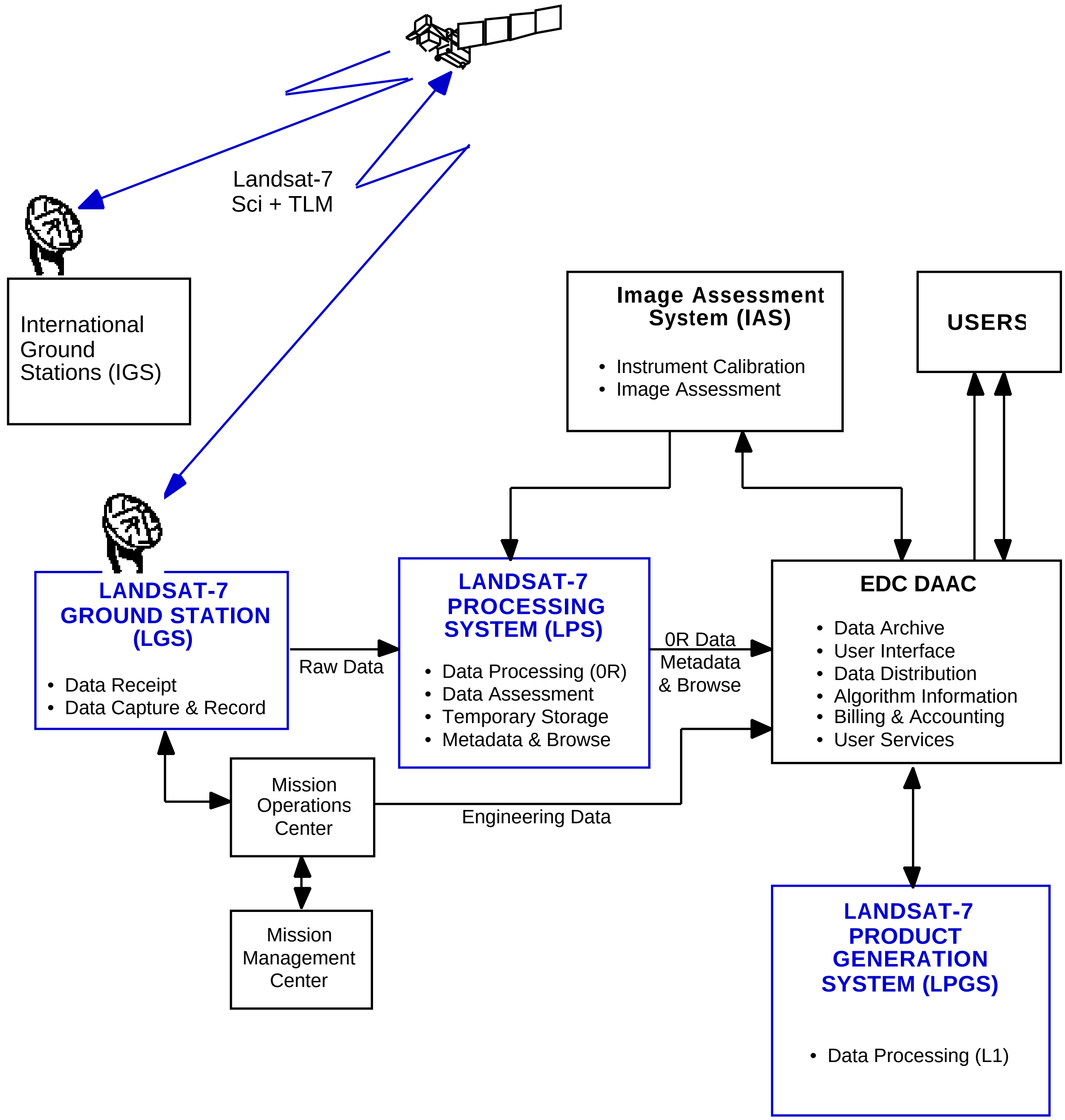

Figure A-2. Landsat-7 Ground Components

support user viewing of the imaged area, and metadata that provides various scene information, including cloud cover assessments and data quality evaluations. The Landsat 7 Product Generation System (LPGS) takes the Level 0R data from the DAAC and creates L1 data sets.

The EDC DAAC interacts with the user community and provides access to Landsat-7 data. The primary interface to the user is via electronic networks, but voice and mail communications are also available. The EDC DAAC interacts with the IAS, distributing ordered data for system evaluation and receiving updated calibration data and its associated metadata.

The IAS is responsible for off line assessment of image quality to ensure compliance with the radiometric and geometric requirements of the spacecraft and ETM+ sensor throughout the life of the mission. The IAS receives Level 0R data and/or ancillary information such as payload correction data, housekeeping data, and browse and metadata from the LPS and the EDC DAAC. These data are assessed in raw form or processed to Level 1R and 1G in IAS and assessed with respect to their geometric, radiometric, and image attract qualities. Trend analysis is conducted. Calibration tables updates and trend analyses reports are passed to the EDC DAAC and IGSs. Anomalies are reported to the mission operations center (MOC) and the LPS.

Landsat 7 data are also downlinked to International Ground Station (IGSs), where additional metadata and browse data are created and provided to the DAAC.

A3 Advanced Earth Observing Satellite

ADEOS II will include the following instruments:

- SeaWinds—Advanced NSCAT
- AMSR—Advanced Microwave Scanning Radiometer

NASDA (Japan) will launch the ADEOS II spacecraft in 1999. NASDA will provide operational control and primary data capture, with the Alaska SAR facility and the AWOTS also providing data acquisition. Data are processed at NASDA and at the SeaWinds Project at JPL, with data products provided to many DAACs.

A4 Earth Orbiter 1 (EO-1)

NASA’s Earth Orbiter 1 will validate technologies contributing to the reduction in cost of Landsat follow-on missions. Once on orbit, EO-1 will provide (00-200) paired scene comparisons between the advanced land imager and the Landsat thematic mapper.

Appendix B. Additional EOS Information

B1 EOS Spacecraft and Science Instruments

EOS is a long-term program to provide continuous observations of global climate change. Repeating flights of the principal EOS spacecraft on 6-year centers will ensure adequate coverage for at least 15 years; however, payloads of the follow-on EOS spacecraft could change, depending on the evolution of scientific understanding and the development of technology.

The EOS Program currently includes nine spacecraft; three morning Sun-synchronous (EOS AM series), three afternoon Sun-synchronous (EOS PM series), and three afternoon Sun-synchronous polar (EOS CHEM series). The EOS AM, PM, and CHEM spacecraft will be placed into 98.2 degree inclined, 705-km, 16 day, 233-orbit repeat cycles, with the EOS AM series having a 10:30 a.m. descending node crossing; the EOS PM series having a 1:30 p.m. ascending node crossing; and the EOS CHEM series, a 1:45 p.m. ascending node crossing. Three smaller spacecraft of the EOS Radar ALT series will be placed into non-Sun-synchronous high-inclination orbits (66 degrees, similar to TOPEX). Medium-light spacecraft of the EOS Laser ALT series will be placed into non-Sun-synchronous orbits at a 94-degree inclination. The SAGE III series will be placed into a high-inclination orbit on the Meteor 3M-1 spacecraft and onto a 57.1-degree inclination orbit on the Space Station.

All spacecraft but the AM-1 will be functionally identical, taking advantage of a common spacecraft bus design to reduce total program cost. The PM-1 spacecraft will be the first to use the common bus design. Figure B-1 summarizes the current EOS mission profile.

The Moderate-Resolution Imaging Spectroradiometer (MODIS) facility instrument is a medium-resolution, cross-track scanning radiometer to measure biological and physical processes. It consists of 36 spectral bands from the visible to the infrared. The presence of MODIS on both the EOS AM and PM spacecraft proves central to the program by providing complete global ocean color measurements through avoidance of Sun glint over the northern oceans and the lack of illumination over the southern oceans. By taking further advantage of the complementary ascending and descending orbits of the AM and PM spacecraft, MODIS provides diurnal sampling coverage and also provides the cloud observations needed to interpret CERES radiation budget measurements, which are also collected by both spacecraft.

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) facility instrument is an imaging radiometer provided by Japan. It will provide high-resolution images of the land surface, water, ice and clouds using 14 spectral bands from the visible through the infrared. The Multi-Angle Imaging Spectroradiometer (MISR) uses CCD cameras and four spectral bands to measure top-of-atmosphere, cloud and surface angular reflectance. Measurements of Pollution in the Troposphere (MOPITT) is a four-channel correlation spectrometer with cross-track scanning.

SAGE III will provide observation of aerosols and temperature from two different orbits. Ocean primary productivity observations are being obtained via a data purchase from the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) onboard the SeaStar spacecraft.

While the majority of the EOS data users are expected to obtain their data from the EOSDIS, real-time MODIS data from the EOS AM series of spacecraft, as well as the entire real-time data stream of the EOS PM series of spacecraft, will be broadcast directly to the ground and available to anyone within line-of-sight of these spacecraft. The data may be received, without charge, by anyone who has obtained or constructed an appropriate ground station.

This Direct Broadcast service will require a moderately sophisticated ground station capable of receiving the signal (a tracking 3-m dish antenna operating in the X-band of 8025-8400 MHz), capturing the data at a rate of 13.125 Mbps for EOS AM-1 (slightly higher for the PM-1 series), and providing all the data processing necessary to produce a usable product. NASA will provide the information necessary to procure or build and operate such a station, but has no responsibility to provide the funding to do so.

B2 AM-1 Mission Characteristics

Planned for launch in June 1998, the EOS AM-1 flight includes five instruments to be placed into a polar, Sun-synchronous, 705-km orbit by an Intermediate Expendable Launch Vehicle. The launch will take place from the Western Space and Missile Center. The payload consists of ASTER, CERES (dual scanners), MISR, MODIS, and MOPITT.

EOS AM-1 will have an equatorial crossing time of 10:30 a.m., when daily cloud cover is typically at a minimum over land such that surface features can be more easily observed. The instrument complement is intended to obtain information about the physical and radiative properties of clouds (ASTER, CERES, MISR, MODIS); air-land and air-sea exchanges of energy, carbon, and water (ASTER, MISR, MODIS); measurements of important trace gases (MOPITT), and volcanology (ASTER, MISR, MODIS). CERES, MISR, and MODIS are provided by the United States; MOPITT is provided by Canada; and ASTER is provided by Japan. The EOS AM-1 spacecraft design (Figure B-2) will support an instrument mass of 1,155 kg, an average power for spacecraft and instruments of 2.5 kW (3.5 kW peak), and an average data rate of 18 Mbps (109 Mbps peak). Onboard solid-state recorders will collect at least one orbit's data for playback through TDRSS, even though a playback on each orbit is planned.

The EOS AM-1 spacecraft will also include the Direct Access System (DAS), which is composed of the Direct Playback subsystem, the Direct Broadcast Subsystem, and the Direct Downlink subsystem. AM-1 data will be recorded and played back via TDRSS, and DAS will provide a backup option for direct transmittal of onboard data to ground receiving stations via an X-band transmitter should the satellite lose its TDRSS link. DAS will also support transmission of data to ground stations of qualified EOS users around the world who require direct data reception. These users fall into three categories:

1. EOS team participants and interdisciplinary scientists who require real-time data to conduct or validate flight observations, to plan aircraft campaigns, or to observe rapidly changing conditions in the field

2. International meteorological and environmental agencies that require real-time measurements of the atmosphere, storm and flood status, water temperature, and vegetation stress

3. International partners who require receipt of data from their high-volume EOS instruments at their own analysis centers for engineering quality checks and scientific studies

The Direct Broadcast subsystem will broadcast MODIS data at 13 Mbps. At this rate, properly equipped ground stations can receive, process, and display the swath data as the EOS spacecraft passes within range.

The EOS AM-1 spacecraft is being developed for NASA by the Lockheed-Martin facilities at East Windsor, New Jersey, and Valley Forge, Pennsylvania. The contractor performs design, construction and testing of the AM-1 spacecraft, provides a spacecraft simulation capability, and provides spacecraft analysis software and data base parameters to the EOC.

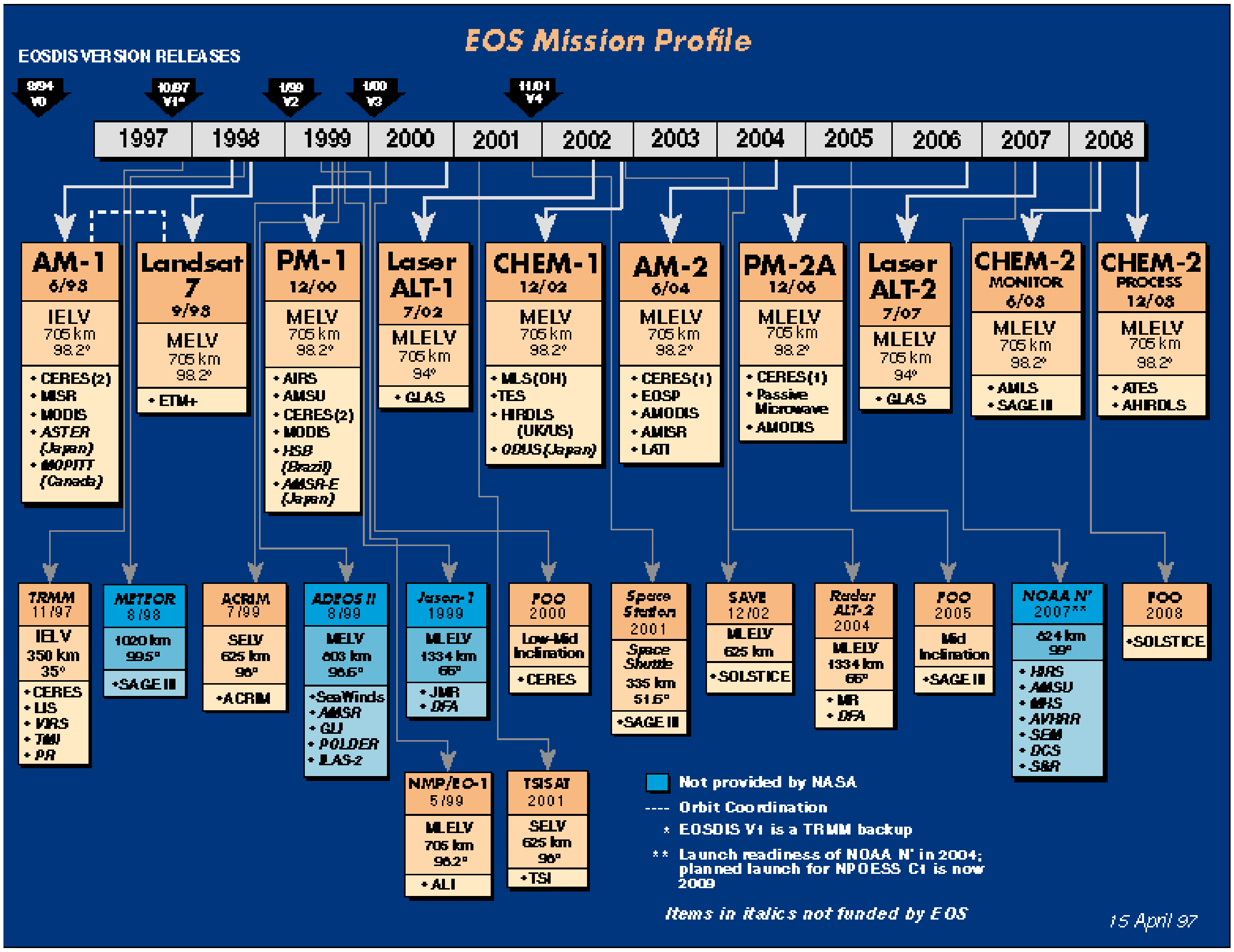

Figure B-1. EOS Mission Profile

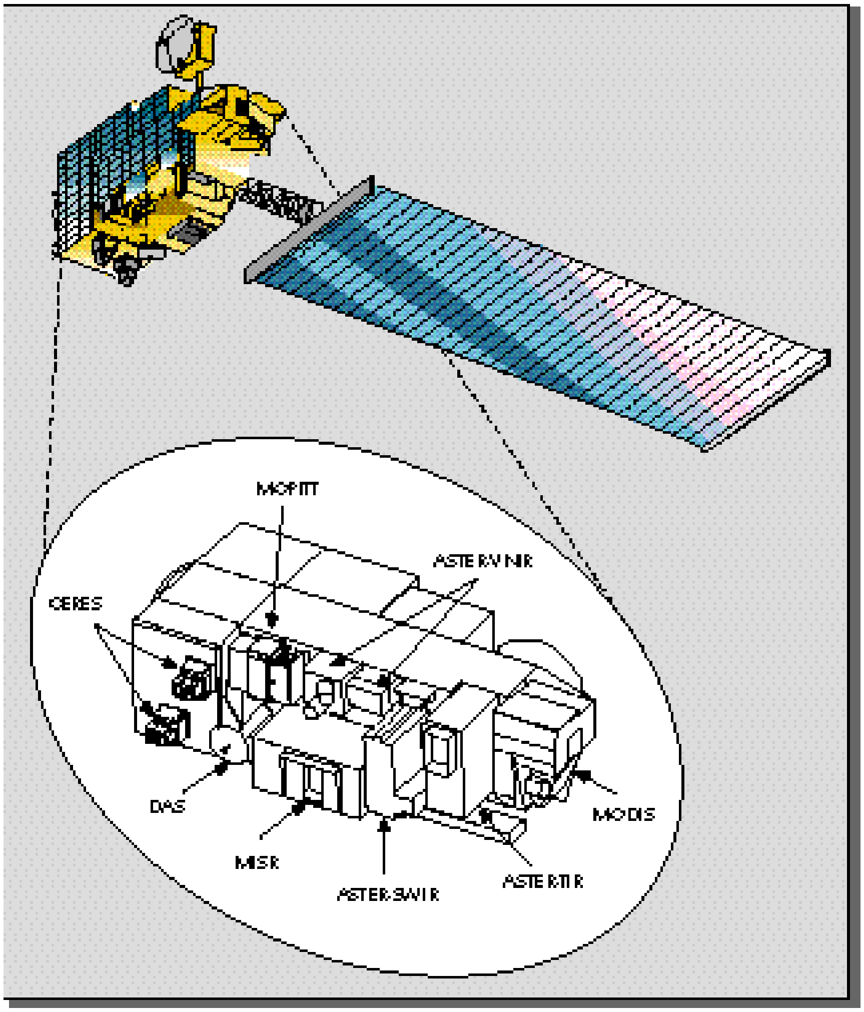

Figure B-2. Payload

Appendix C. EOSDIS Development

C1 EOSDIS Core System (ECS)

C.1.1 ECS Overview

The ECS is a major contribution to EOSDIS. The ECS provides the planning and scheduling, command and control, data processing and management, data archiving and management, system management, communications management, networking, and data distribution functions required to support EOS operations and data access. The ECS comprised the Flight Operations Segment (EOC and IST), the Science Data Processing Segment (Client, Interoperability, Data Management, Data Server, Ingest, Planning, and Data Processing), and the Communications and Systems Management Segment. The ECS makes data available to the user community and stores and manages data returned from them.

Using the ECS as their window to EOSDIS, the science community is able to access data from DAACs in the United States and from other international Earth science support systems. It is anticipated that a large community of users will access ECS services. Users are allowed to browse the service, order advertised products, request data processing, and propose the integration into the ECS environment of new algorithms.

Figure C-1 shows the ECS component of EOSDIS and its relationship to other EOSDIS components.

C.1.2 Major Design Drivers for ECS

ECS development is being accomplished in cooperation with the user community, with a shared commitment to the vision of an information system that promotes effective utilization of data across the entire Earth science community. During the ECS architecture design phase, a set of requirements models and architecture models were produced that allocated the Level 3 requirements to each of the ECS subsystems. These models formed the basis for performing an Object-Oriented Analysis (OOA) and Object-Oriented Design (OOD). The specification for each subsystem, which consists of the subsystem identification and its allocated Level 3 requirements, was used to define the problem domain and carry out the OOA.

The development of the system may be mapped into four iterative phases: Analysis, System Design, Object Design, and Implementation. In addition, the evolutionary process allows for feedback into subsequent releases and all phases that preceded it, for a continuous refinement of the system. Each phase involves trades in optimizing functionality and performance against cost, schedule, and technical objectives.

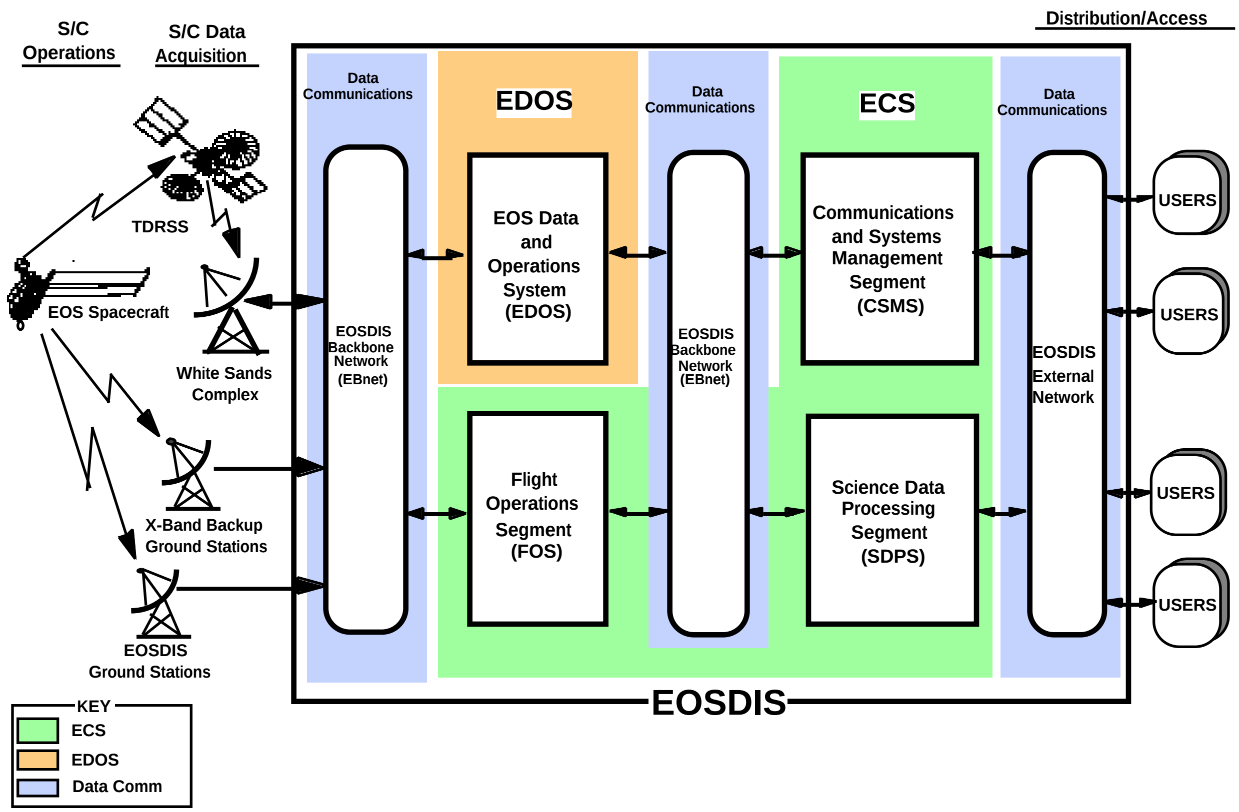

Figure C-1. EOSDIS Showing Major Contributed Parts

The ECS design must be compliant with the overall system-wide requirements as described in the ECS System Requirements Document (216-SE1). The ECS requirements cover the following categories: operations, functional, performance, external interfaces, security, reliability, maintainability, and availability, and evolvability. Each segment's description of its design either explicitly or implicitly addresses these requirements. The following paragraphs discuss the major design drivers.

C.1.2.1 System Evolvability

The development of ECS uses an evolutionary process. Many of the concepts underlying evolutionary development are those of evolutionary development of naturally occurring systems, such as natural selection. The ECS development process explicitly uses the notion of natural selection through iterative development both within a release cycle—the Incremental Development track—and from release to release—adapting to user and operator feedback on the previous release.

The goal of developing ECS into an evolvable system is to provide a highly adaptable system that is responsive to the evolving needs of the Earth science community and to enable this system to be changed economically. System evolvability is defined as the ability of a system, design, or architecture to accommodate changes to the requirements, design, or implementation in a timely and cost-effective manner.

Over the ECS system lifetime (at least two decades beyond the launch of the first EOS spacecraft), evolution will come from at least three separate sources:

1) Scientific needs will change as Earth system science matures and new applications of the data emerge.
2) Information system technologies must be refreshed as maintaining older technologies becomes more difficult and new technologies emerge in their place.
3) Changes in the information infrastructure will lead to migration of functions to take full advantage of these capabilities (high bandwidth networking)

To accommodate these evolutionary drivers, ECS will

- Accommodate growth in all of its functions, as well as the addition of new functions
- Be expandable with respect to storage and processing capacity for instrument data products and algorithms
- Be extended by unique capabilities developed by the individual data centers, tailored to the needs of their user communities, and be designed to promote cost-effective development of such extensions

User, data, and performance modeling activities are performed in support of the ECS system design. User modeling establishes the size and scope of the EOSDIS user community and characterizes how it interacts with the system. Data modeling characterizes the data to be managed by EOSDIS and how they are used. Performance modeling uses the results of the user and data modeling and a variety of timing and sizing analyses to assess different system architectures and investigate specific functional and performance requirements issues.

The results of user, data, and performance modeling activities are represented by the data characterization information that has been provided to the design team. Individual outputs, including user scenarios, data product analysis, metadata definitions, and system sizing information, were provided as direct inputs to ECS development activities

C.1.2.2 Verification, Integration and Testability Considerations

The ECS verification program employs an organized approach to unit testing. For integration and test (I&T), a build/thread methodology is used in which capabilities are aggregated into ever larger pieces. This does not fundamentally influence the basic design. Instead, it influences the order in which the design components are implemented. For acceptance testing, a science and operations scenario methodology is employed. Additionally, the verification program utilizes four methods of verifying requirements and analysis of test results: inspection, analysis, demonstration, and test.

C.1.2.3 Reliability, Maintainability, and Availability

ECS RMA requirements are met through the implementation of a formal RMA program plan. RMA requirements are also flowed down to all COTS vendors as part of the COTS RMA evaluation and procurement process. During the design phase, requirements compliance is demonstrated through analysis such as prediction; system availability modeling; and Failure Modes, Effects, and Analysis. Initial RMA predictions are acquired from COTS equipment vendors and by prediction methodology in the case where vendor data are not available.

C.1.2.4 Project Standards and Procedures

The system and segment engineers use the ECS Standards and Procedures Document (202-SE1) to determine what standards exist and have been recommended for use in a specific service class category or area. These ECS service class categories include programming, user interface, data management, data interchange, graphics, network, operating system services, system management, and security. Part of the decision in selecting a design technology is to evaluate the applicable standards. As the system or segment engineers assess the list of standards, they are presented with standards that are formal, consortia, de facto, and proprietary. They are also presented with standards that have been selected for use on the project, standards that are emerging and are tracked or are candidates for use on the project, and standards that supersede standards that have been selected and are being evaluated. Maintaining and using a set of ECS standards aids interoperability and evolvability for the ECS design.

C.1.2.5 Application Programming Interfaces Requirements Compliance

APIs are a set of library routines that provide program-wide access to particular ECS services. To support configuration control, APIs are treated as internal interfaces until system release and a separate interface control document (ICD) are developed describing usage of APIs. The ICDs describe any usage sequences and constraints and include description of environmental requirements consisting of COTS, network interfaces, and memory needs.

To better serve the science community, APIs provide configuration-controlled APIs to allow science users to develop extensions that manipulate ECS data products and to interface with ECS interoperability services to become service providers. In addition, use of configuration controlled APIs allows easier reuse of ECS components for the Global Change Data and Information System (GCDIS).

The development of interfaces among ECS components, EOSDIS components, and extension to GCDIS components, and the nature of the interoperability that is facilitated by the ECS architecture presented, makes the development of APIs and their associated ICDs a natural part of the baseline design effort.

C.1.2.6 Version 0 Incorporation in ECS

Five Version 0 component types have been considered for potential incorporation into the ECS: hardware, software, design, experience, and process. Advantages of the integration of hardware and software include lower risk and earlier release schedule. The benefits of design integration have been evaluated against the potential limitations of a particular implementation. An advantage of building on an acceptable design is that it can lower the risk of usability. Even if the tangible components, hardware, software, and design are not enveloped, the experience and processes that were identified by the Version 0 Team have incalculable value for ECS development.

C2 EDOS

C.2.1 EDOS Overview

EDOS is an EOS data handling and delivery system maintained and operated by GSFC. GSFC is also managing development and implementation. EDOS provides capabilities for handling data for EOS spacecraft that adhere to recommendations established by the CCSDS. Specifically, EDOS provides capabilities for return link data capture, data handling, data distribution, archival data storage, and forward link data handling. EDOS supports ground/ground data communications for data delivery using advanced protocols consistent with a set of approved protocols. Reliance of EDOS on these space/ground and ground/ground standards facilitates mission interoperability and results in lower life-cycle costs for NASA. EDOS serves as a single point of contact for EDOS customers for data assurance, operations management, and fault management. EDOS supports all levels of MO&DSD and EOS end-to-end testing in preparation for EOS spacecraft launch readiness by utilizing the operational system without interrupting ongoing operations.

EDOS is distributed over several facilities as follows: three GSIFs located respectively at the WSC near Las Cruces, New Mexico, and at northern ground stations at Alaska and Norway; the LZPF and the SEF at GSFC, Greenbelt, Maryland, and the DAF. EDOS communications interfaces with EOS ground facilities and other EDOS facilities are via EBnet.

Figure C-2 shows the EDOS functional architecture.

C3 EBnet

C.3.1 EBnet System Description

EBnet is the ground-to-ground data transport system for operational EOS communications. EBnet project implementation is the responsibility of the NISN. EBnet includes forward link commanding, return link telemetry and science payload data, and EDOS-to-DAACs rate buffered, expedited, and production files. EBnet also includes communication support between the EOC and NASA institutional systems for the support of SN scheduling (NCC) and spacecraft orbit and attitude determination (FDF). EBnet also supports EOS contingency communications through connections to the northern ground stations and WOTS.

C.3.2 EBnet Functional Overview

Figure C-3 is a functional representation of EBnet. EBnet provides communications service through three major functions: transport, network management, and engineering support. The following subsections describe these functions.

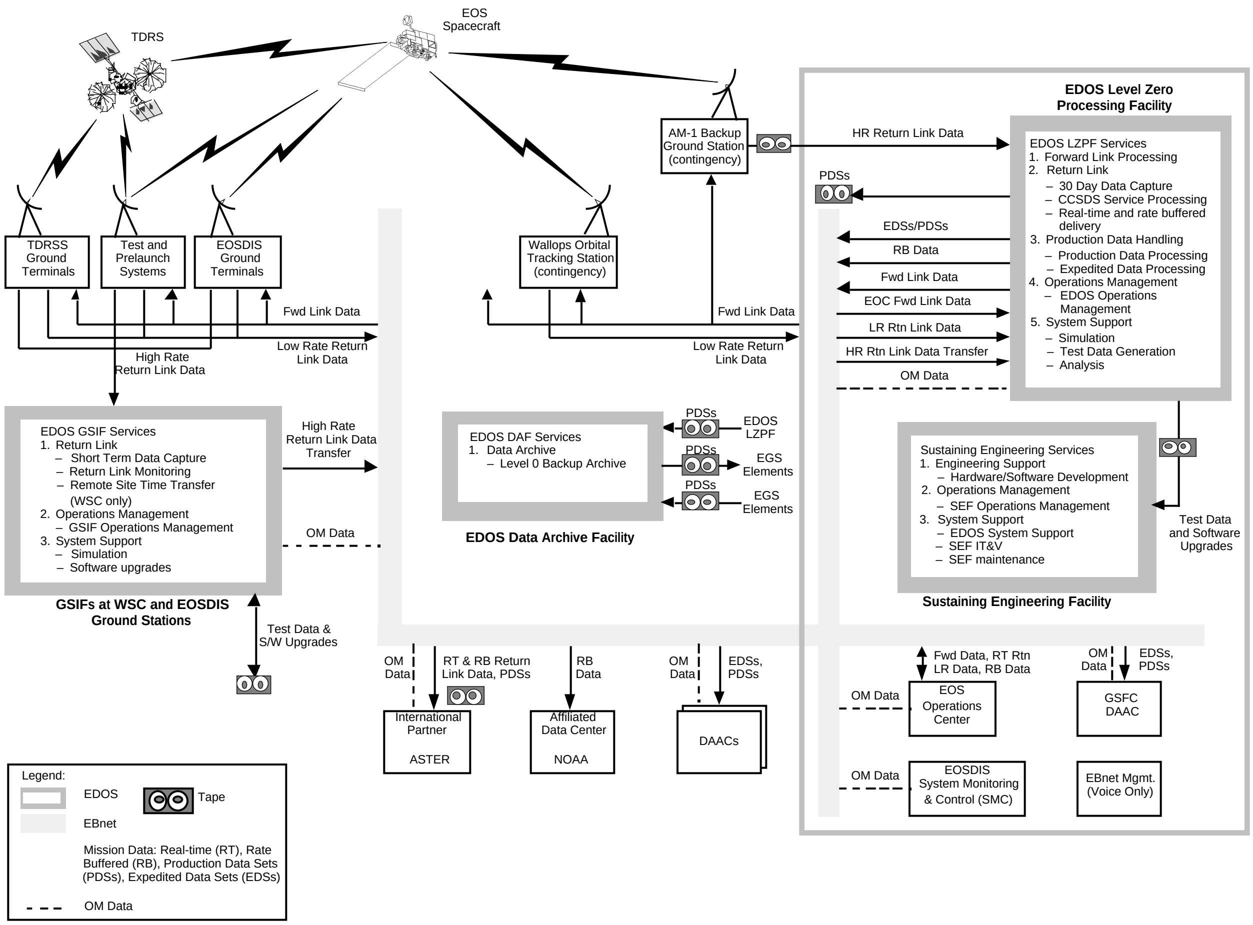

Figure C-2. EDOS Functional Architecture

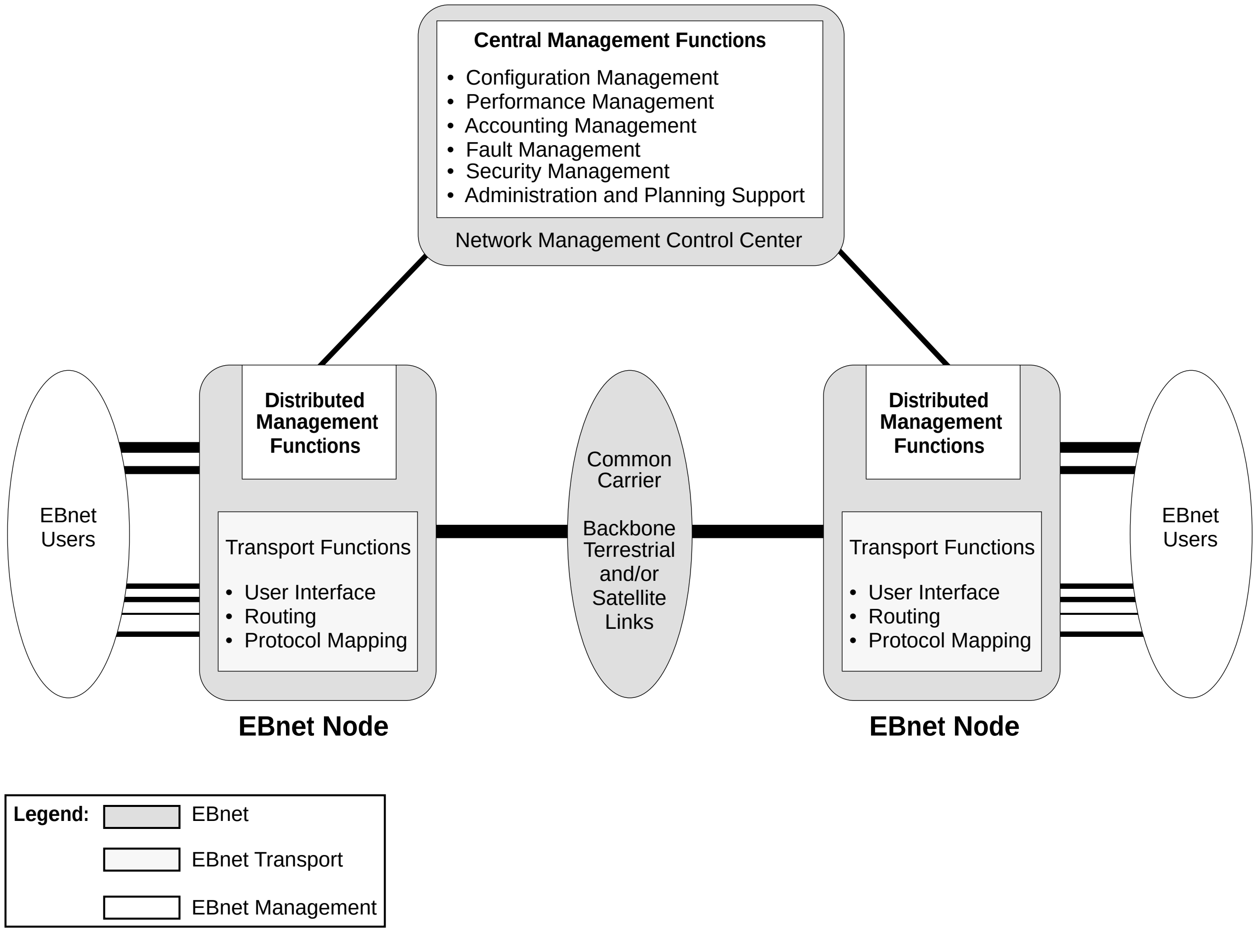

Figure C-3. EBnet Conceptual Architecture

C.3.2.1 Transport

The Transport Function (TF) provides an interface to the user, routes user data, and provides an interface to the common carrier. The term “user” generically identifies a specific source or destination of EBnet traffic. Transport functions physically reside in an EBnet node. Each location that requires EBnet service has an EBnet node installed at the user facility. Nodes are interconnected by commercial common carrier service providers. The TF supports an IP interface to the user and routes user data on the basis of the protocol information that comes across the interface (i.e., it is a data-driven versus a scheduled system.)

C.3.2.2 Network Management Function

The Network Management Function (NMF) provides the capability to manage EBnet. The NMF comprises functions that are distributed in the nodes and centralized functions at the EBnet NMCC located at GSFC. Nodal equipment has the capability to monitor itself, report status to the NMCC, and respond to commands from the NMCC. The functions at the NMCC include configuration, performance, accounting, fault, and security management. The NMCC supports an interface with the EDOS operations management function that provides EDOS with enough information to support its management interface with users.

C.3.2.3 Engineering Support Function

The Engineering Support Function (ESF) provides EBnet with the capability to perform sustaining engineering of the EBnet system, including planning, analysis, modeling, testing, and a development environment. The ESF is housed in the SEF at GSFC. The ESF also supports an interface to the EDOS SEF so that hardware or software changes made to the EDOS/EBnet management or data interfaces can be tested before integration into the operational environment.

Abbreviations and Acronyms

ACL	access control list
ADC	affiliated data center
ADD	architecture description document
ADEOS	Advanced Earth Observing Satellite mission series (Japan)
AM	EOS Morning (AM) Crossing Mission series
AMSR	Advanced Microwave Scanning Radiometer
AM-1	first spacecraft in the EOS AM series
AOS	acquisition of signal
	Advanced Orbiting System
API	application programming interface
APID	applications process identifier
ARC	Ames Research Center
ASF	Alaska SAR Facility
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer (Japanese instrument)
AVNIR	Advanced Visible and Near-Infrared Radiometer
C&DH	command and data handling
CADU	channel access data unit
CCSDS	Consultative Committee for Space Data Systems
CERES	Clouds and the Earth's Radiant Energy System
CHEM	EOS Chemistry Mission series
CI	configuration item
CLTU	command link transmission unit
CM	configuration management
CNE	Center Networking Environment
Co-I	Co-Investigator

COTS	commercial off the shelf
CSCI	computer software configuration item
CSMS	Communications and System Management Segment (ECS)
CSS	Communications Subsystem
DAAC	Distributed Active Archive Center
DADS	Data Archive and Distribution System
DAF	data archive facility, EDOS
DAO	Data Assimilation Office
DAS	direct access system
	data assimilation system
DBMS	database management system
DDICT	data dictionary
DPR	Data Processing Request
DRP	Data Reduction Platform
DIM	data information manager
DRP	Data Reduction Platform
DSN	Deep Space Network
EBnet	EOSDIS Backbone Network
ECS	EOSDIS Core System
EDC	EROS Data Center
EDOS	EOS Data and Operations System
EDS	expedited data set
EDU	electronic data unit
EGS	EOS Ground System
EMC	Enterprise Monitoring and Coordination
EOC	EOS Operations Center (ECS)
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EPG	EOS Polar Grounds Network

EPGN	EOS Polar Ground Network
ESA	European Space Agency
ESDIS	Earth Science Data and Information System
ETM	Enhanced Thematic Mapper
ETS	EOS Test System
FDD	Flight Dynamics Division
FDF	Flight Dynamics Facility (GSFC)
FLID	First Look Input Data
FMEA	Failure Modes and Effects Analysis
FOO	Flight of Opportunity
FOT	flight operations team
GCDIS	Global Change Data and Information System
GCRP	Global Change Research Program
GDS	Ground Data System (ASTER)
GN	Ground Network
GSFC	Goddard Space Flight Center
GSIF	Ground Station Interface Facility
GUI	graphical user interface
HDF	Hierarchical Data Format
HIRDLS	High-Resolution Dynamics Limb Sounder
HK	housekeeping
HRS	High Rate System (ETS)
IAS	image assessment system
ICC	instrument control center
ICD	interface control document
IGS	International Ground Station
II	interdisciplinary investigator
IMG	Interferometric Monitor for Greenhouse Gases
IMS	information management system

IONET	IP Operational Network
IP	international partner
	Internet Protocol
IRIS	Incorporated Research Institutions for Seismology
IST	Instrument Support Toolkit (ECS)
	Instrument Support Terminal (EOSDIS)
IV&V	independent verification and validation
IWG	Investigator Working Group
JEST	Java Earth Science Tool
JPL	Jet Propulsion Laboratory
KSA	Ku-Band Single Access
L0	level 0 (data)
LAN	local area network
Landsat	Land Remote-Sensing Satellite
LaRC	Langley Research Center
LATIS	Langley TRMM Information System
LGS	Landsat-7 Ground Station
LIM	local information manager
LIS	Lightning Imaging Sensor
LPS	Landsat Processing System
LPGS	Landsat Product Generation System
LRS	Low Rate System
LSM	local system manager (ECS)
LTIP	long-term instrument plan
LTSP	long-term science plan
LZPF	level zero processing facility
M&O	maintenance and operations
MISR	Multi-Angle Imaging Spectroradiometer
MMO	Mission Management Office (Landsat)

MOC	mission operations center
MODIS	Moderate-Resolution Imaging Spectroradiometer
MOPITT	Measurements of Pollution in the Troposphere
MOU	memorandum of understanding
MPS	multimode portable simulator (ETS)
MSS	System Management Subsystem
MTPE	Mission to Planet Earth
NASA	National Aeronautics and Space Administration
NI	NASA Internet
NASDA	National Space Development Agency (Japan)
NCC	Network Control Center (GSFC)
NCEP	National Center for Environmental Protection
NESDIS	National Environmental Satellite, Data, and Information Service
NISN	NASA Integrated Service Network
NISS	NASA Institutional Support Systems
NMC	network management center
NMCC	Network Management Control Center
NOAA	National Oceanic and Atmospheric Administration
NOLAN	Nascom Operational Local Area Network
NSCAT	NASA Scatterometer
NSI	NASA Science Internet (former name for NI)
NSIPO	NASA Science Internet Project Office
O&M	operations and maintenance
ODC	other data center
ODPR	On-Demand Production Request
OOA	Object-Oriented Analysis
OOD	Object-Oriented Development
P&S	Planning and Scheduling
PDB	Project Data Base

PDS	production data set
PGE	Product Generation Executive
PGS	Product Generation System
PI	principal investigator
PM	EOS Afternoon (PM) Crossing Mission series
POLDER	Polarization and Directionality of Reflectances Precipitation Radar
PR	precipitation radar
PSAT	predicted site acquisition table
QA	quality assurance
QC	quality control
RMA	reliability, maintainability, and availability
RTS	real-time server
SAS	Spacecraft Analysis Software
SAVE	Solar Atmospheric Variability Experiment
S/C	spacecraft
SCC	Spacecraft Control Computer
SCF	Science Computing Facility
SCITF	Spacecraft Integration and Test Facility
SDP	Science Data Processing
SDPF	Sensor Data Processing Facility (GSFC)
SDVF	Software Development and Validation Facility
SDPS	Science Data Processing Segment (ECS)
SEF	Sustaining Engineering Facility
SMA	S-Band Multiple Access
SMC	System Management and Coordination Center (ECS)
SN	Space Network
SNMP	Simple Network Management Protocol
SSA	S-Band Single Access

SSIM	Spacecraft Simulator
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TF	Transport Function
TIROS	Television and Infrared Observation Satellite
TL	team leader
TLM	telemetry
TM	team member
TMI	TRMM Microwave Imager
TOMS	Total Ozone Mapping Spectrometer
TOO	target of opportunity
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission
TSDIS	TRMM Science Data and Information
TSS	TRMM Support System
USGCRP	United States Global Change Research Program
VCDU	virtual channel data unit
VIRS	Visible Infrared Scanner
WFF	Wallops Flight Facility
WGS	Wallops Ground System
WOTS	Wallops Orbital Tracking Station (former name for WGS)
WSC	White Sands Complex (New Mexico)